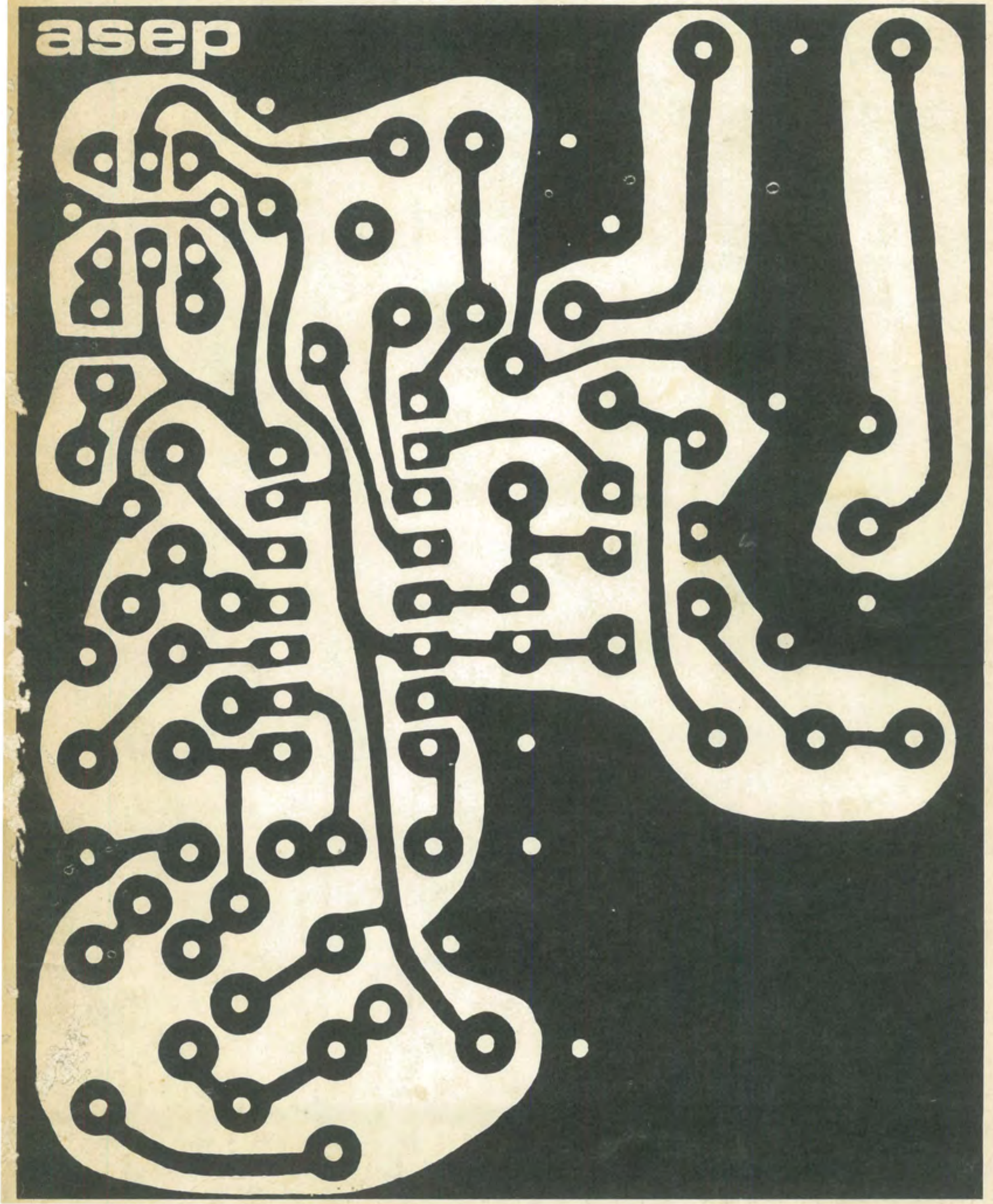
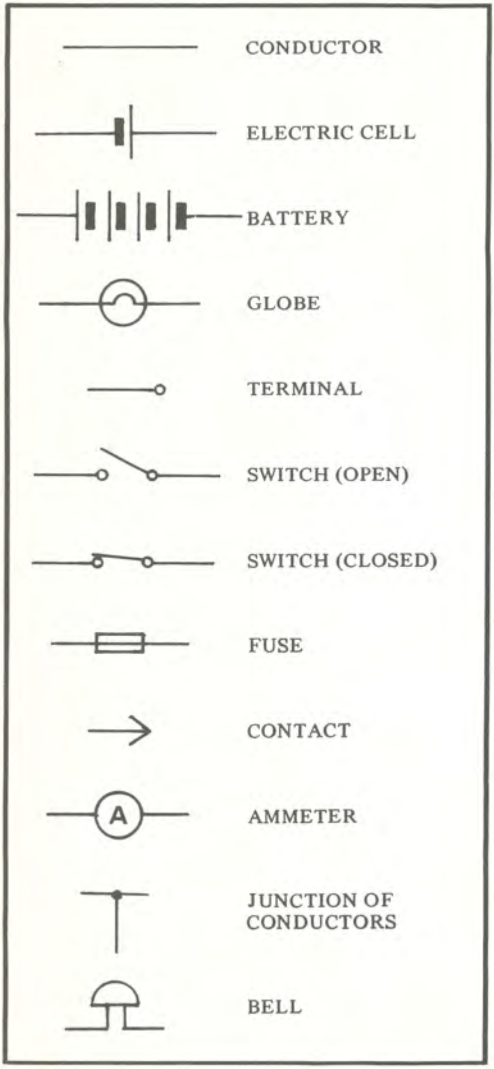
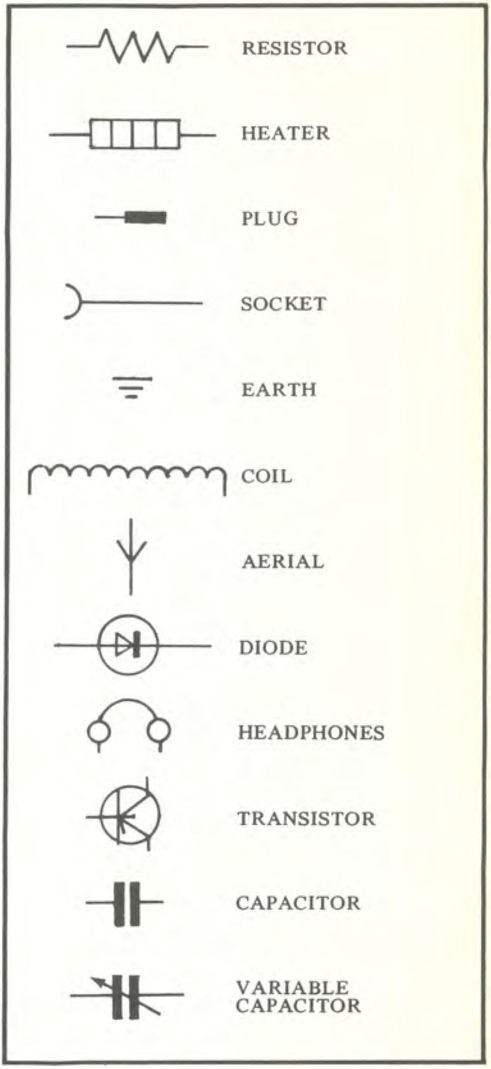
Electric Circuits

asep



The symbols below for circuit components (parts) are recommended by the International Electrotechnical Commission (IEC), and published by the British Standards Institution in *B.S. 3939*. The symbols are used in *Electric Circuits.*





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Electric Circuits consists of two books—this book and a record book. This book begins with a section called Simple Circuits, and every student needs to do this. Other sections called options follow. You can choose which options you want to do.

In *Electric Circuits* you are asked a number of questions, which you should try to answer in your record book. Whenever you see the sign ✍, it means that you will need to write or draw something in your record book.

Try to answer every question. You can check your answers in the back of this book. If your answers are different from those given, talk things over with another student or a teacher before going on.

Simple Circuits

You have possibly switched on electric lights, or toasters, or stoves often.

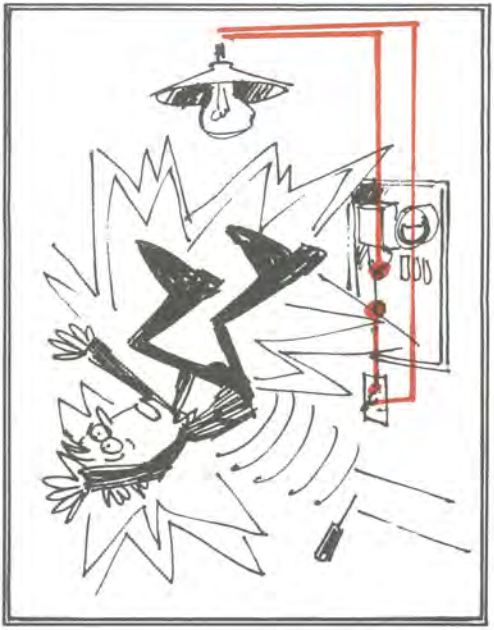
If you look around you now, you may be able to see something which uses electricity.

In *Electric Circuits* you are going to find out about the things that electricity does. You will be using cells* which produce only small amounts of electricity. It would be too dangerous to use electricity from power points for the investigations you will be doing.

You will find it useful most of the time to work with a partner.

On the table on page 2 of your record book, fill in the date when you start *Electric Circuits.* As you finish each section, keep this table up to date.

*** Words in bold type and underlined are explained in the glossary, page 99.**



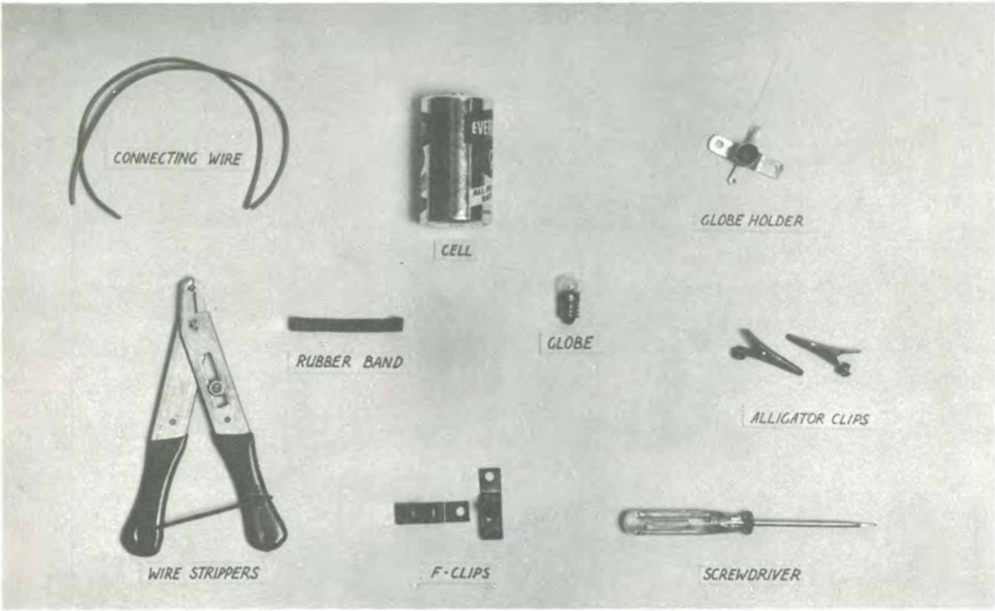
ACTIVITY 1: MAKING A GLOBE LIGHT UP

You will need:

- 1 cell
- 1 rubber band
- 2 F-clips
- 1 globe
- 1 globe holder
- 2 pieces of connecting wire, each about 20 cm long
- 2 alligator clips
- 1 screwdriver
- 1 pair of wire strippers.

Strip about 2 centimetres of the insulation from both ends of each wire. (One of the wall charts shows how to do this.)

Using the equipment listed at left, try to make your globe light up.



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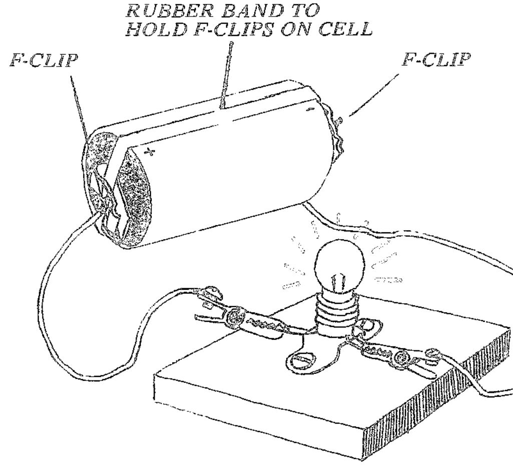
Activity 1 continued next page

If you have been unsuccessful, connect the components as shown in the diagram below. (Look at the wall charts showing how to connect wire to an alligator clip and how to connect an F-clip to a cell.)

It is easier to work with a globe if the globe holder is attached to a base.

CIRCUIT 1



What would happen to the globe if you took a wire off the cell? Try it!

ACTIVITY 2: SWITCHES

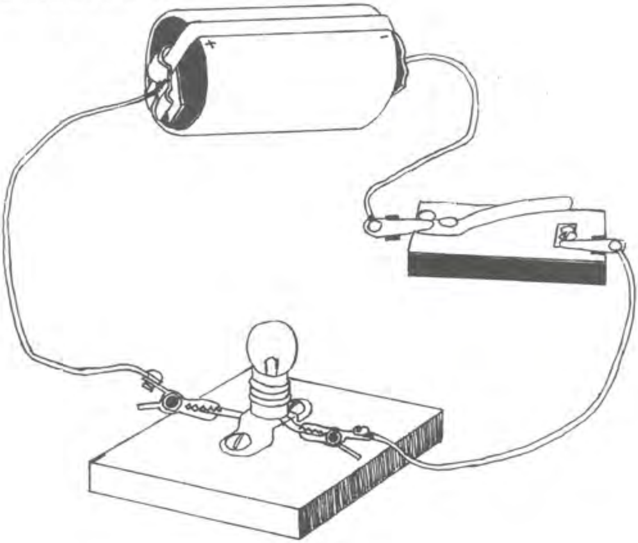
Here is a way of switching the globe off more easily (and also of stopping the cell from going flat quickly).

You will need:

- all the things you have used so far
- 1 extra globe and globe holder
- 2 extra alligator clips
- 2 extra pieces of connecting wire
- 1 press switch.

Try connecting these bits of equipment as shown in the diagram below.

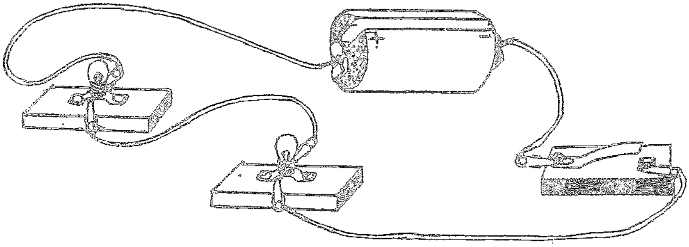
CIRCUIT 2



1 What was necessary to make the globe light up in Circuit 2? Give your answer on page 4 of your record book.

Activity 2 continued next page

CIRCUIT 3



Add another globe, as shown in the diagram above.

Look carefully at the globes when you press the switch down. What seems to have happened to the brightness of the globes? Can you think of any reason for this? Discuss these questions with your partner.

2 What did you see happen to the brightness of the globes when you had two globes in the circuit instead of one?

Electric current flows from the cell through the wires, switch, and globes and back to the cell again. If you run around an oval, you do a circuit of the oval. The path the current takes in flowing from a cell and back to the cell is called an electric circuit.

For a circuit to be complete, electric current must flow through the cell, too.

When the switch in Circuit 3 is closed is there a complete circuit (a complete path) if you take one wire away from the cell? Try this to see what happens.

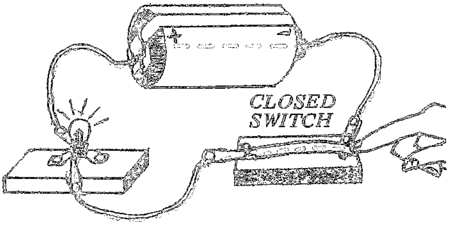
When there is no complete path, electric current doesn't flow. We say the electric circuit is not complete--or the circuit is broken.

3 Turn to page 4 of your record book and answer questions 3a and 3b.

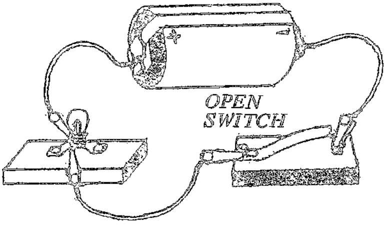
Find out what happens when you unscrew one globe from its holder.

4 What have you done by taking out one globe? Give a brief explanation.

The globe is part of the circuit, too.



Current can flow through the above circuit because the switch is closed, making the circuit complete.



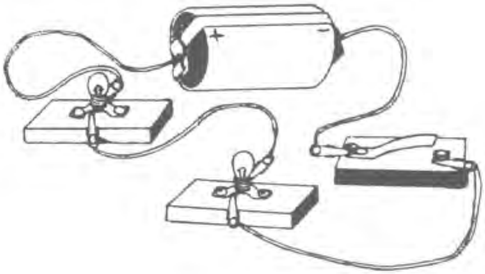
The switch in the circuit above is open, so the circuit is not complete.

ACTIVITY 3:
JUMBLING THE CIRCUIT

Does it make any difference where the switch is put in a circuit like Circuit 3?

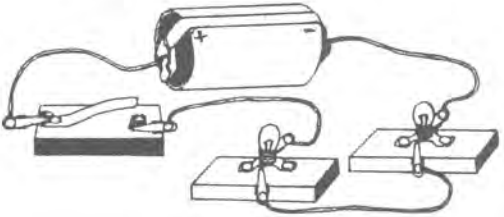
You can try to find out by altering the position of the switch and closing the switch to complete the circuit.

CIRCUIT 3



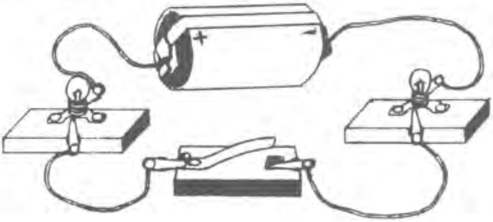
Change the switch to the new position, as shown at right.

CIRCUIT 4



Now put it in another new position as shown at right.

CIRCUIT 5



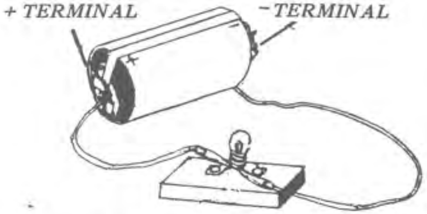
In each of these circuits, the switch and globes are connected one after another like links in a chain. This is called a series connection. If you change the position of components the circuit will still work.

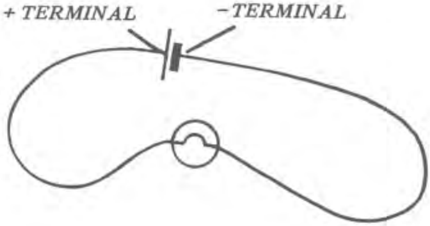
CIRCUIT DIAGRAMS

So far, the diagrams of circuits have shown drawings of cells, globes, etc. But not all cells look alike. Nor do all globes and switches. So that electricians all over the world can 'read' circuit diagrams, symbols are used to represent the components in a circuit. The use of symbols also makes circuit diagrams easier to draw.

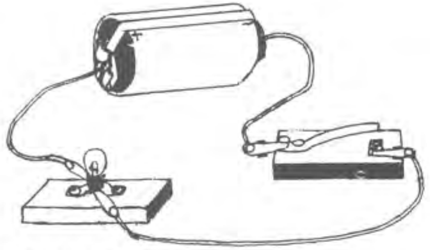
Notice that the + terminal of a cell is represented by the longer and thinner of the two strokes.

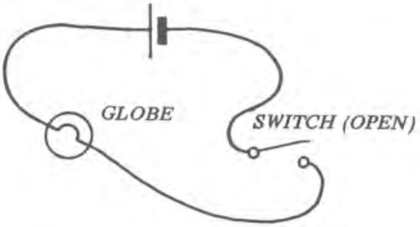
ORDINARY DIAGRAMS **DIAGRAMS USING SYMBOLS**



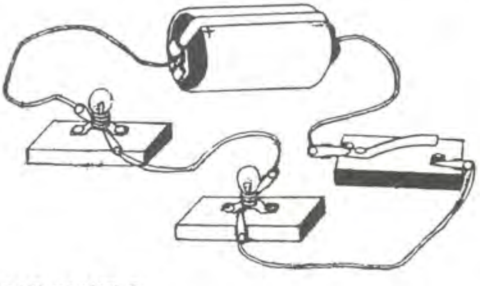


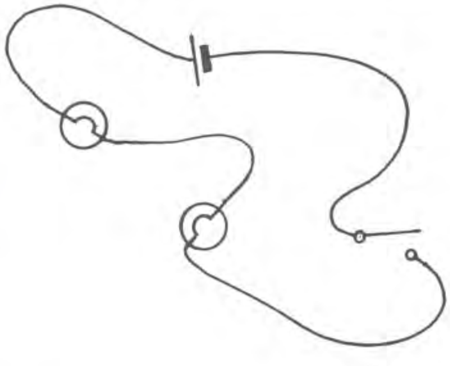
CIRCUIT 1





CIRCUIT 2



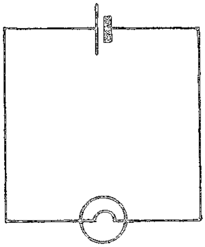


CIRCUIT 3

Usually, however, electricians go one step further than this with symbols. They draw all the connecting wires either straight or with right-angle bends. These diagrams are called circuit diagrams.

The symbol diagrams on the opposite page are usually drawn like those below.

CIRCUIT DIAGRAMS



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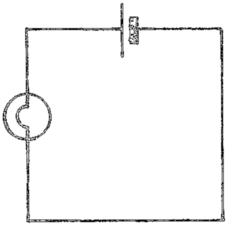

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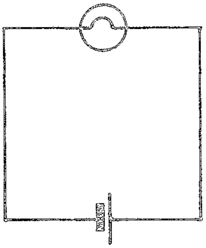

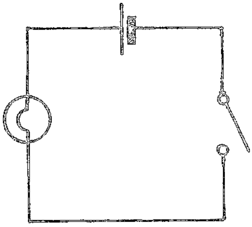

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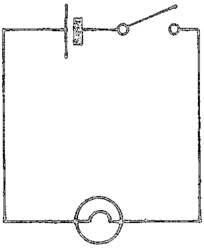

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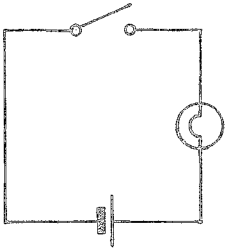

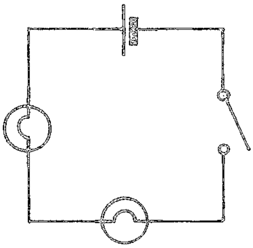

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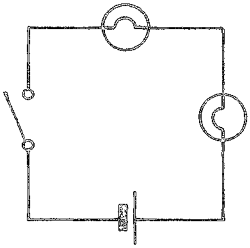

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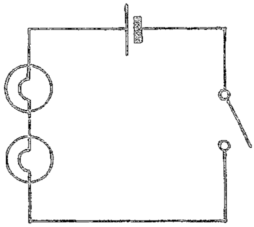
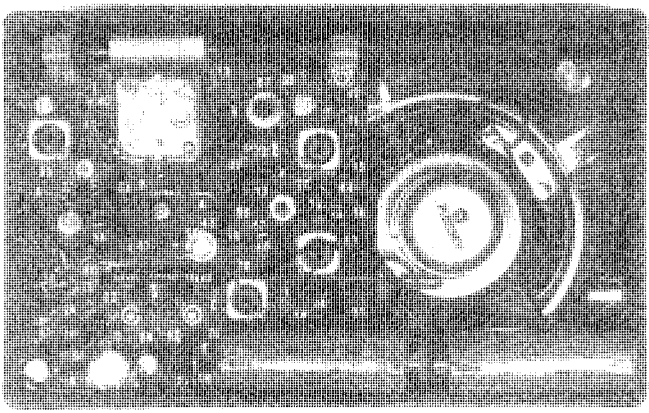
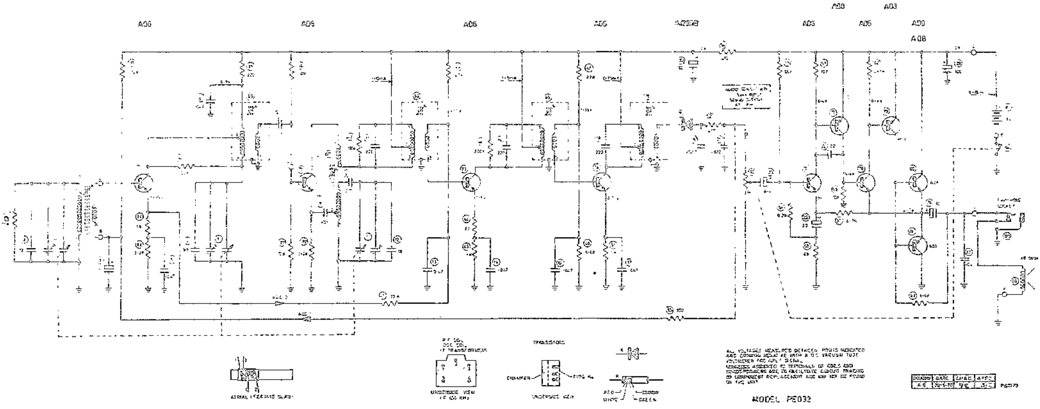


Circuit Diagrams contined next page



This photo shows some of the parts of a transistor radio. When a circuit is complicated like the one in this radio, it is easier to follow if it is drawn as a circuit diagram (below).



5 On page 5 of your record book, try to describe the circuit in the diagram there.

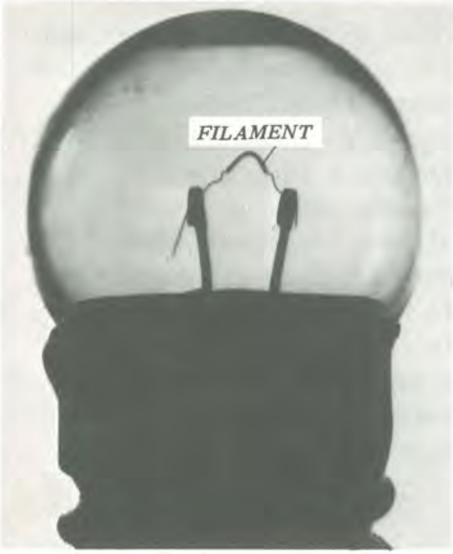
6 Describe the symbols on page 5 of your record book. Refer to page 2 of this book if you're not sure what the symbols are.

7 Try to draw a circuit diagram showing a cell and two globes.

8 Try to draw a circuit diagram of a cell in series with a switch and a globe.

9 Which of the circuit diagrams on page 7 of your record book does not represent a circuit with a cell followed by a globe, then a switch, then another globe?

ACTIVITY 4: WHAT'S IN A GLOBE?



In this activity, you can look more closely at the type of globe you have been using.

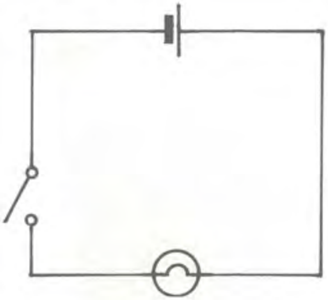
You will need:
- 1 globe
- 1 hand lens.

Look through the hand lens at the globe. The part that lights up is called the **filament**.

10 On page 7 of your record book, try to draw the filament.

You can see that the filament is made of thin wire. This wire is part of the electric circuit when the filament is glowing. Why do you think the filament is shaped the way it is? Discuss this with your partner or another student.

CIRCUIT 6



You can now examine the filament when it is glowing.

Collect the equipment you will need to set up Circuit 6, shown at left. Connect the circuit.

With the switch open, hold the hand lens so that you can see the filament clearly. Keeping the hand lens in this position, close the switch. Keep opening and closing the switch until you are sure which part of the filament glows.

11 On your drawing of the filament, label the part which glows when the circuit is complete.

ACTIVITY 5:
WHAT THINGS WILL ELECTRIC CURRENT FLOW THROUGH?

You will need:

- 1 cell, rubber band and F-clips
- 1 ammeter
- 1 globe in holder
- 5 pieces of connecting wire
- 4 alligator clips.

The photo below shows different types of **ammeters.**

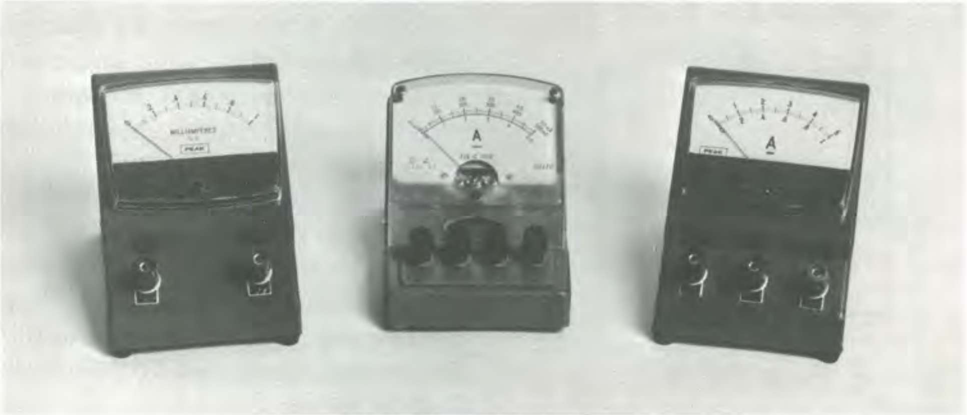
An ammeter is an instrument which is used to show how much electric current is flowing. It can detect a current which is not even sufficient to make a globe light up.

Ammeters can have different numbers of terminals. They all have one + terminal, but can have one, two or more - terminals.

Each type of ammeter must be connected in a special way.

Connect the + terminal of the cell to the + terminal of the ammeter, as shown in the diagram on page 15. (The + terminal is marked in red or with a +.)

If your ammeter has more than one - terminal, ask a teacher which one you should connect.



Three different types of ammeters. As you can see, ammeters can have different numbers of terminals.

S'funny This ammeter was working a minute ago
I wonder why it isn't now?

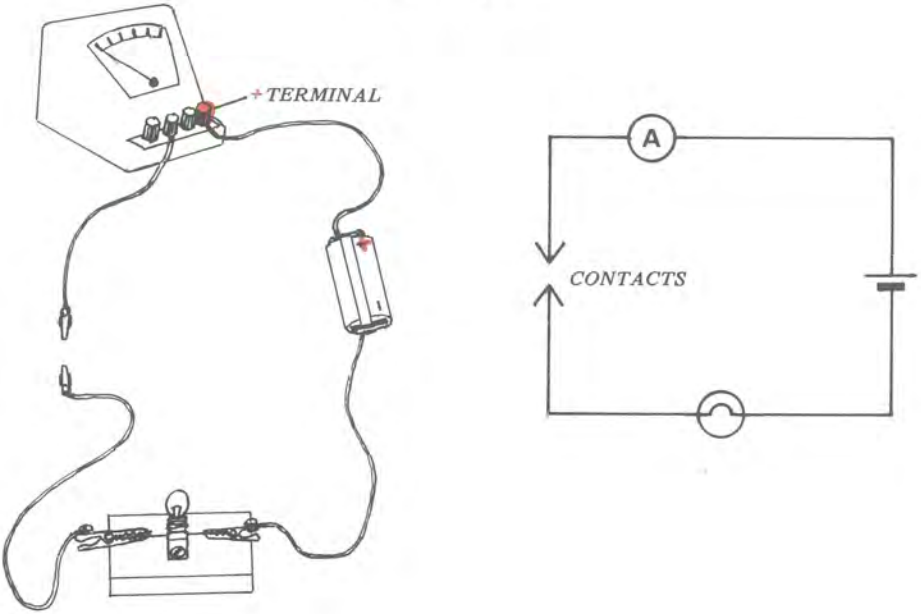
WARNING: Before you put anything between the 'spare' alligator clips, ask a teacher to check the way you have connected the circuit. If the ammeter is not properly connected, it may be damaged when current flows through it.

Connect the circuit as shown in the diagrams below.

Clip the two 'spare' alligator clips together.

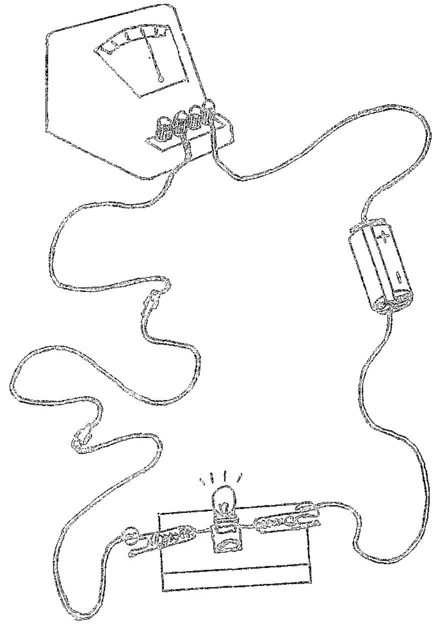
Watch the ammeter and the globe when the 'spare' alligator clips make contact.

CIRCUIT 7

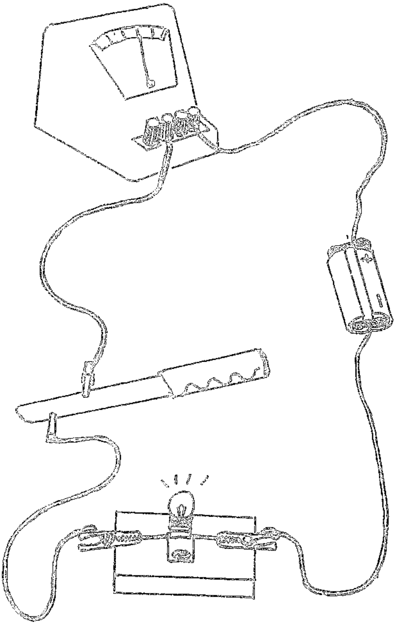


Now you are ready to find out how much electric current will flow through certain things.

Activity 5 continued next page



Connecting wire is a CONDUCTOR because electric current can flow freely through it.



A knife blade is a LOW-RESISTANCE CONDUCTOR.

For the first test, clip the remaining piece of the connecting wire between the contacts ('spare' alligator clips) as shown at left. Notice what happens to the globe and the ammeter.

Now you can try other things between the contacts. While you are doing this it is important to watch the ammeter needle when the circuit is being completed. If you look at the ammeter after the circuit has been completed, it could look as if no current is flowing. What you should look for is movement of the needle as contact is made. It may be necessary to 'make and break' the circuit a few times before you are sure.

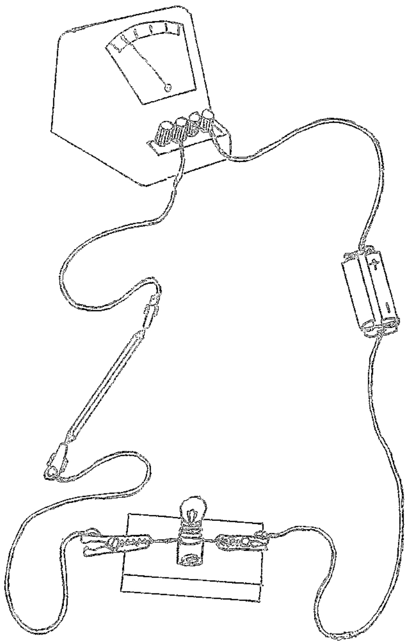
Now turn to page 8 of your record book, where there is a list of materials you could try between the contacts. You could try anything else you can think of.

12 As you try things between the contacts, record your observations (with ticks) in the spaces in the table.

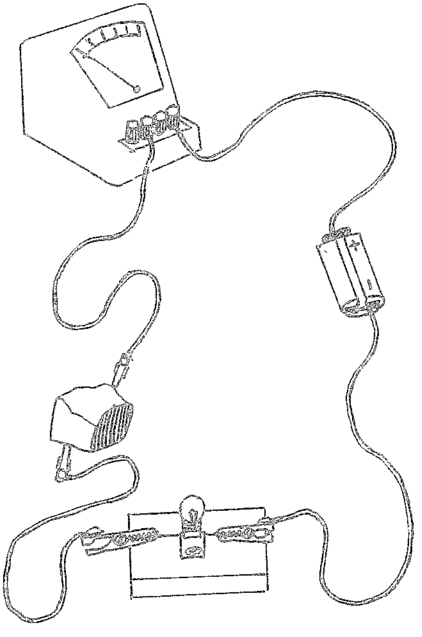
Things through which electric current flows are called conductors.

You probably noticed that for some materials, the globe didn't light up, but the needle on the ammeter moved a little. These materials allowed less current to flow through them than did the materials which allowed the globe to light up.

All materials in circuits resist the flow of current to some extent. That is, all materials have a resistance to the flow of electric current.



The globe is not glowing, but the ammeter needle has moved. Pencil lead is a HIGH-RESISTANCE CONDUCTOR.



This rock is an INSULATOR—a conductor with a very high resistance.

The materials that you tested can be put into three groups.

Group A: Globe lit up; needle moved.

Group B: Globe didn't light up; needle moved.

Group C: Globe didn't light up; needle didn't move.

Materials in Group A allowed current to flow fairly freely through them. That is, they didn't resist the flow of current very much. They are called low-resistance conductors.

Materials in Group B allowed some current to flow, but less than materials in Group A. They are called high-resistance conductors.

Materials in Group C didn't appear to allow any current to pass through them. (At least, the ammeter you used didn't detect any.) Materials like this have a very high resistance, and are often called insulators.

The higher the resistance of a substance, the smaller will be the electric current that can flow through it.

13 Under the group headings on page 9 of your record book, list the materials you tested.

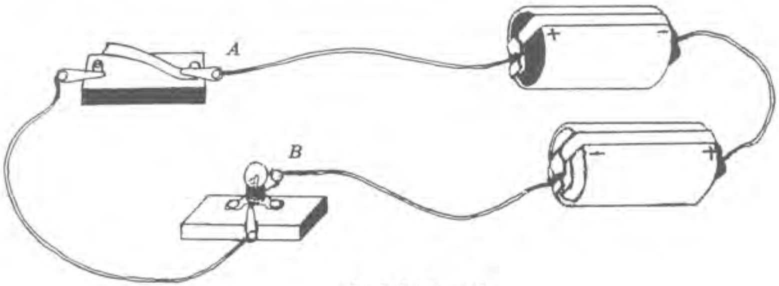
ACTIVITY 6: SHORT CIRCUITING

What happens when a circuit is 'shorted'? This activity will help you to find out.

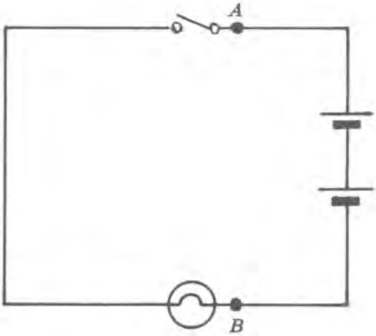
You will need:
- 2 cells and 2 rubber bands
- 4 F-clips
- 4 alligator clips
- 4 pieces of connecting wire
- 1 switch
- 1 globe and holder
- 1 screwdriver
- 1 pair of wire strippers (or a file).

Before you connect Circuit 8, strip a further 1 centimetre or so of insulation from the wires at A and B.

Then connect the circuit as shown below.

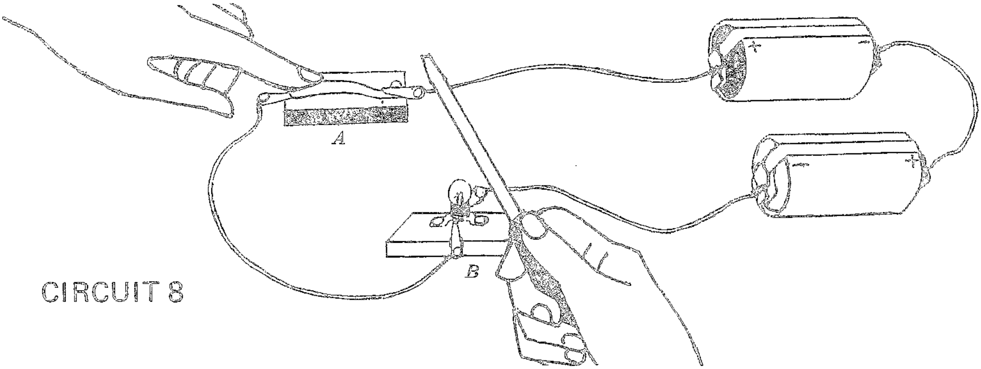


CIRCUIT 8



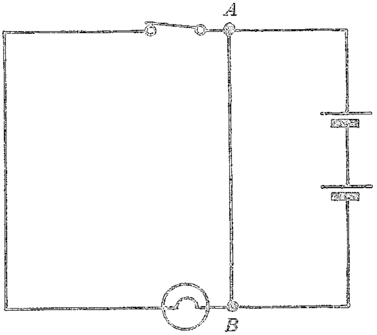
Close the switch. Now, place the screwdriver blade on the bared wires. You are 'joining' A to B with the screwdriver. This is called a short circuit.

As soon as you notice something happen, take the screwdriver away again.



CIRCUIT 8

14 In your record book, describe what you noticed when you shorted the circuit and took the screwdriver away again.



Try to trace the path of the current when the screwdriver was on the wires.

The resistance of the screwdriver blade is much lower than the resistance of the rest of the circuit. As a result, most of the current flows through the short circuit—that is, the circuit with the lower resistance. Only a very small amount flows through the switch and the globe.

When the screwdriver is in position, more current flows through the circuit. The cells are likely to go flat quickly. The connecting wires in the shorted circuit might get hot.

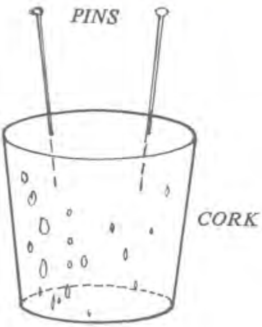
Often, the current which flows through a shorted circuit is too much for safety. But if there is a fuse in the circuit, the fuse becomes hot and melts. This breaks the circuit before the current becomes large enough to be dangerous.

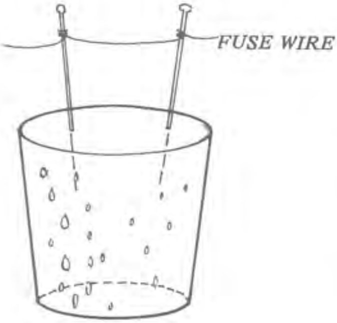
ACTIVITY 7:
A FUSE IN A CIRCUIT

You will need:

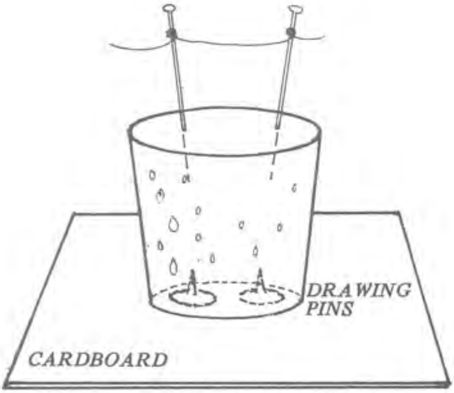
- all the equipment you used in Activity 6
- 1 cork
- 2 pins
- 2 lengths of fuse wire, each about 5 cm long
- cardboard
- 2 drawing pins
- 2 extra alligator clips
- 1 extra piece of connecting wire.

Here is how to make a fuse which can be used in circuits with cells. Follow the diagrams at left.



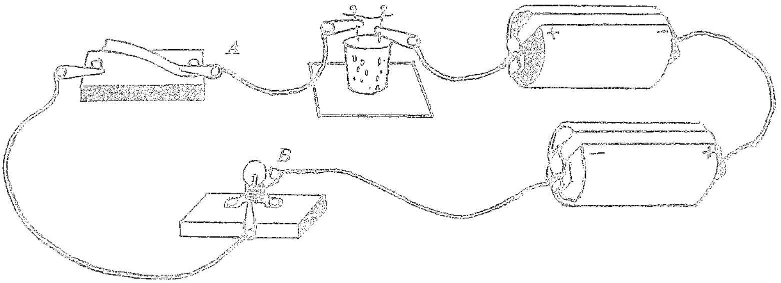


Make sure that the fuse wire makes firm contacts with the pins. To do this, wind the wire around the pins several times.

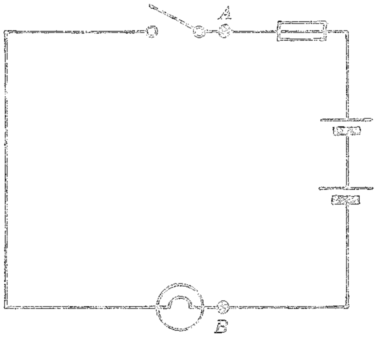


Poke the drawing pins through the cardboard. Push the cork on to the prongs of the drawing pins so that the cork is flat on the cardboard.

If you now connect Circuit 9 (below), you will be able to see what the fuse does. Make sure that the bared sections of the wire are in the positions shown on the diagrams.



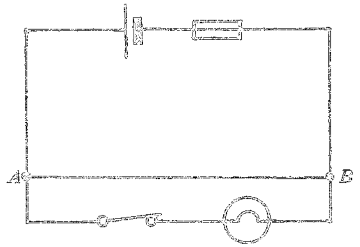
CIRCUIT 9

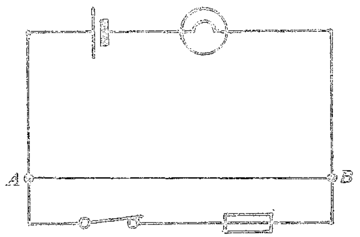


Close the switch. Now, short the circuit across AB by putting the screwdriver there, as you did with Circuit 8.

Replace the fuse wire and try it again.

The fuse breaks the circuit and so protects the rest of it when current starts to flow through the short circuit.





15 Copy the two circuit diagrams shown at left on to page 10 of your record book. Draw in red the path the current will take if the circuits are shorted across AB.

16 Near each diagram, state whether the globe will or will not go out when the circuit is shorted, and whether the fuse will or will not 'blow'.

ACTIVITY 8: SETTING UP CIRCUITS

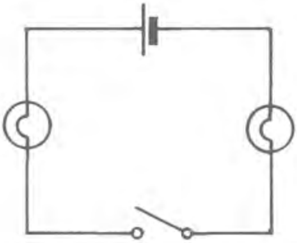
This activity is to give you practice in setting up circuits from circuit diagrams.

If you are working with a partner, you may like to go about it like this:

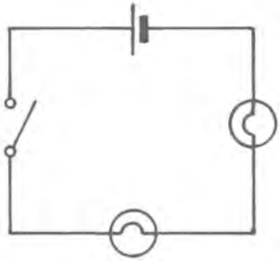
One partner could set up Circuit 10 while the other sets up Circuit 11. When you have both finished, you could check each other's circuits.

Then you could both go on to Circuits 12 and 13, and so on.

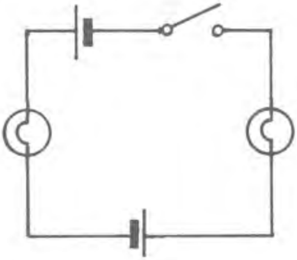
CIRCUIT 10



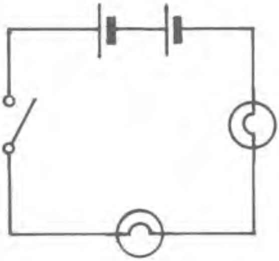
CIRCUIT 11



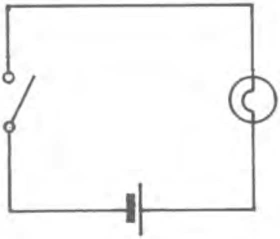
CIRCUIT 12



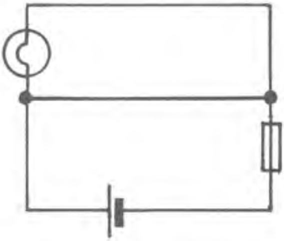
CIRCUIT 13



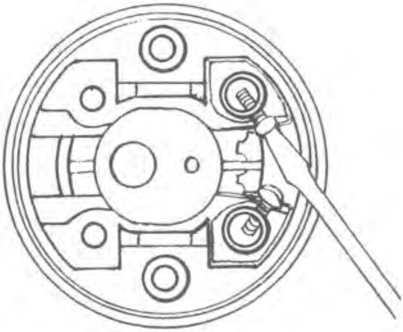
CIRCUIT 14

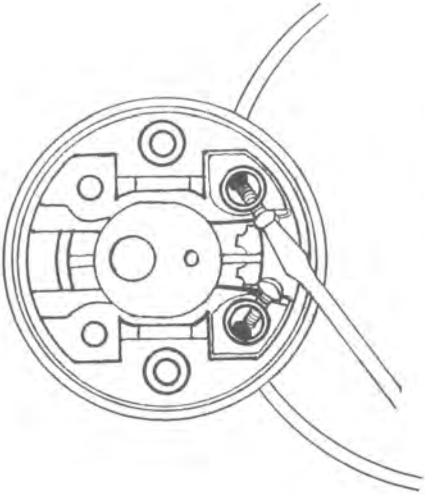


CIRCUIT 15



ACTIVITY 9: HOUSEHOLD SWITCHES





You have been looking at things quite different from the switches, wires and globes used in houses. In this activity you can see if household appliances work in a way similar to the equipment you have been using.

You will need:
- 1 cell
- 1 rubber band
- 2 F-clips
- 1 globe and holder
- 2 alligator clips
- 1 household switch
- 3 pieces of connecting wire.

Connect two pieces of the wire to the switch, as shown at left.

Then set up the cell, globe and switch in series.

When you have connected the circuit, trace the path along which the current is flowing. Is there still a complete circuit?

✎ 17 What is the difference between the way in which the household switch works and the way a press switch works?

✎ 18 Why is the outside of the switch made of plastic?

In a home, there still must be a complete circuit. The electricity supplied to a house can be dangerous. To reduce this danger, the wires are covered by a sheath of insulation and are enclosed in plastic or metal pipes.

☠ **WARNING: It is dangerous (and in some States, illegal) to tamper with switches which are in household circuits.**

Activity 9 continued next page

Warning as Five Die from Electrocution

Five people have been electrocuted in Victoria this summer.

The chief electrical inspector for Victoria (Mr. G. T. Cuthbert) said yesterday that hot weather demanded stricter observance of safety rules for electrical appliances and equipment.

Two of the people killed were using portable electric tools, while standing barefooted on concrete or earth.

A third person was using an electric tool while kneeling on wet concrete.

Safe If . . .

Mr. Cuthbert said there was little danger of electric shock if flexible cords were correctly wired.

But should there be any fault in the wiring, people in bare feet or wearing very little clothing were more likely to receive a shock.

Mr. Cuthbert said both the appliances and the leads used should be carefully checked and care should be taken to ensure they were connected to a properly earthed power outlet.

(Reprinted with permission from The Age, *Melbourne, 17 January 1965.)*

ELECTRICITY KILLS 10

TEN people died in NSW last year while attempting do-it-yourself repairs of electrical appliances, according to the Electricity Authority of NSW.

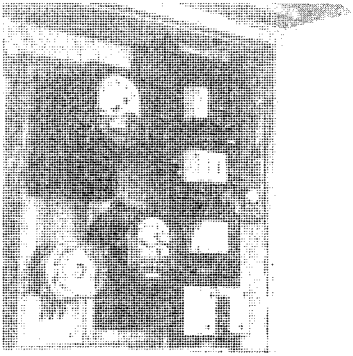
(Reprinted with permission from the Sunday Telegraph, *Sydney, 4 March 1973.)*

Broken switches are dangerous. A person using a broken switch could touch a live wire (a current-carrying wire) or some metal part inside. He might become part of a complete circuit himself, and receive a severe electric shock which could cause death. (Electrocution means death resulting from an electric shock.)

Linesmen wear insulated clothing and work with tools that have insulated handles. If they accidentally touch a live wire, the insulation protects them from becoming part of a circuit.

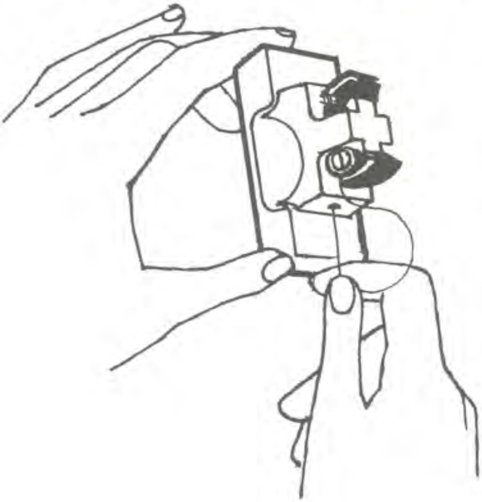
You don't have to touch a second wire to complete a circuit. If you are in contact with something which can become a conductor, electric current can flow through you and then back to the source of the current.

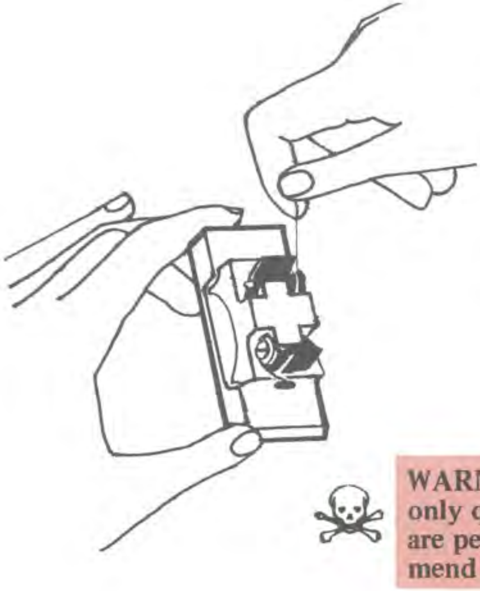
The electricity supply in a house comes through a switchboard like the one shown below. Usually, switches, fuses and meters are all together in the switchboard, but sometimes they are at different locations. The whole switchboard is usually built inside a cupboard, sometimes called a fuse box or a meter box.



Switchboard for a household electricity supply.

ACTIVITY 10: HOUSEHOLD FUSES





You have seen fuses break circuits when too much current flowed through them.

Now you can look at some household fuses.

You will need:

- 1 fuse carrier
- 1 card of fuse wire.

Look at the fuse carrier. Then look at the card of fuse wire. The different kinds of wire on the card will be labelled 8 A and 15 A (or 8 amp and 15 amp).

Wire up the fuse carrier, as shown in the diagrams at left.

Thick fuse wire (15 A) is used for appliances which use a large current, such as electric stoves and hot water systems and for power-point circuits. The thin fuse wire on your card (8 A) is used for light circuits. Thick fuse wire can take a greater current flowing through it before it melts.

There are other types of **circuit-breakers**, too. These automatically break the circuit when too much current flows. Large switchboards usually have circuit breakers, while small switchboards have fuses.

Check to see if the switchboard where you live has fuses or circuit breakers. (Do **not** touch anything inside the switchboard case.)

WARNING: In some States, only qualified electricians are permitted by law to mend household fuses.

USING ELECTRICITY SAFELY

Read through the press clipping at right. Also read the press clippings on page 24 if you haven't already done so.

Most accidents are due to carelessness.

Imagine two trouble-shooters who have different ways of handling electrical problems. Call them 'Careful Charlie' and 'Stupid Sparky'.

Stupid Sparky is much faster than Careful Charlie. Sparky goes straight to the trouble . . . and often ends up in serious trouble himself!

The sort of thing Stupid Sparky does is shown in the diagram below right. There he is trying to remove a piece of burning toast which has jammed in a toaster.

He is doing three stupid things:

☐ He has left the toaster switched on.

☐ He is using a knife with a metal handle.

☐ His right hand is almost touching the metal frame of the toaster.

19 What do you think Careful Charlie would do in a situation like this?

Cause

The Australian Fire Protection Association has detailed records of 250 fires which occurred in multiple occupancy buildings. The causes were:

Air-conditioning systems	2
Blow lamps	2
Decomposition of celluloid	3
Electrical faults	28
Electrical appliances	31
Exposure from fires in adjoining buildings	5
Fireworks	2
Flammable liquids	16
Hot flues	2
Gas appliances	12
Incendiarism	13
Incinerators, disposal of rubbish and hot ashes	23
Kerosene heaters	3
Open flames	3
Overheating	5
Refrigerators	1
Rodents	1
Smoking	47
Sparks (non-electrical)	4
Spontaneous ignition	9
Welding operations	1
Causes not recorded	36

(Reprinted with permission from The Australian, *15 December 1970.)*

If the knife touches the heating **element** *of the toaster, current may flow through Stupid Sparky to the metal frame of the toaster.*

Imagine that there is an electric jug which doesn't work when it's switched on.

Careful Charlie says: 'Turn off the switch and remove the plug. Examine the jug and the lead to the jug. You may find something unusual. The lead may be worn or even hot. If something seems wrong with either the lead or the jug, get an electrician to fix it.'

Perhaps the jug and the lead appear to be all right. In that case, the fuse has probably blown.

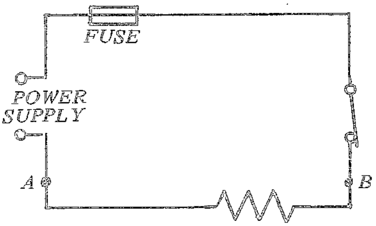
Careful Charlie says: 'Turn off the main switch and look at the fuses on the switchboard. If the fuse for the power-point circuit has blown, then the jug is probably faulty. Call an electrician to fix the fuse—and the jug, if necessary. Do not use the jug again until it has been repaired. The fuse probably blew because the jug was faulty.'

Stupid Sparky says: 'Fix the fuse with anything—a nail, a piece of wire or a coin. Don't bother with fuse wire, because fuses are a nuisance. They don't blow when you put wire or nails in them.'

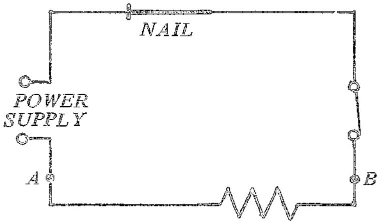
If you follow Stupid Sparky's advice, the circuit will not be protected if a short circuit occurs.

Using Electricity Safely continued next page

CAREFUL CHARLIE'S CIRCUIT



STUPID SPARKY'S CIRCUIT



Stupid Sparky doesn't think twice about turning things on or off with wet hands.

20 Which part of Careful Charlie's circuit gets hot first if there is a short circuit across AB?

21 Which part of Stupid Sparky's circuit gets hot if there is a short circuit across AB?

22 'A fuse is necessary in every household circuit for safety reasons,' says Careful Charlie. What could happen if a household circuit did not contain fuses?

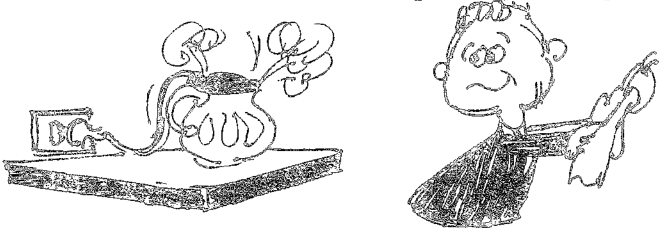
Look at the illustrations below.

23 What is dangerous about touching switches or electric appliances with wet hands?

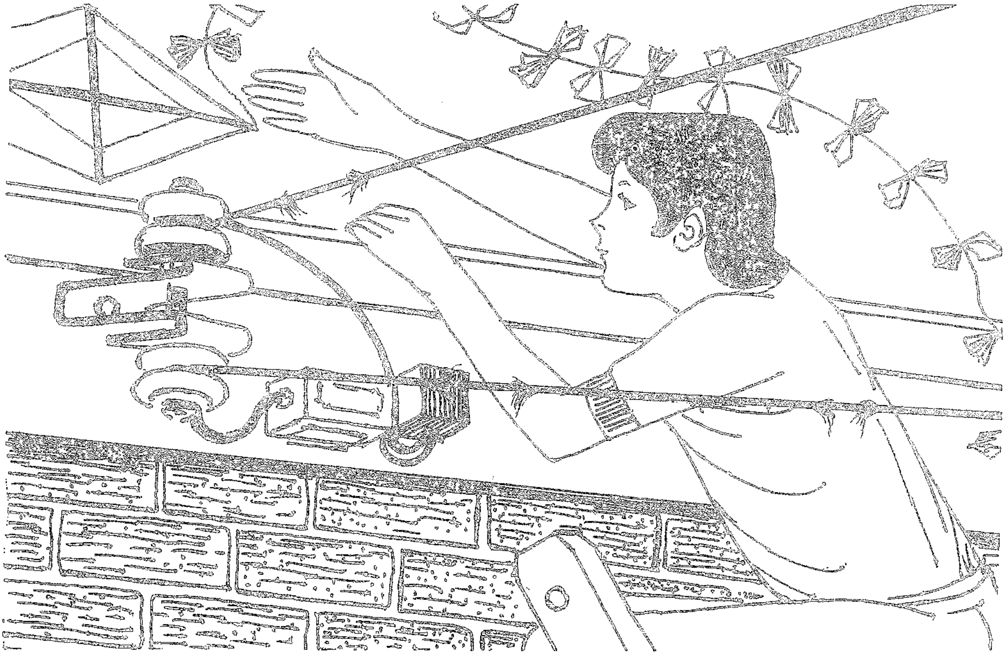
Remember: A fuse doesn't protect a person who becomes part of a household circuit.

Before a fuse blows, a large current must flow through it. If you cause a short circuit, then the current must flow through your body before the fuse will blow.

Electric wires are covered with an insulator to protect you. Fuses stop parts of a circuit from getting too hot and possibly causing a fire.



Careful Charlie always makes sure he has dry hands before touching a switch or an electric appliance.



24 Look at the diagram above. Try to explain what is dangerous about what the boy is doing.

Electricity supplied to houses has to be used with great care because it can cause fires and harm people. Cells usually are not dangerous.

CELL	HOUSEHOLD POWER
No fuse needed.	A fuse needed in every circuit.
No need to cover all wires.	All wiring has to be protected with insulation.
Simple switches will do.	Proper household switches needed.

You can check your answers by turning to page 89 of this book.

TEST YOURSELF–SIMPLE CIRCUITS

This test is to help you find out if you understand what you have been doing–so it is important that all your answers are your own work. It is not a test for marks.

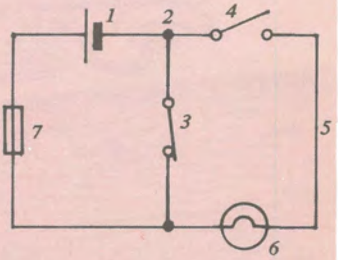
Answer the following questions on page 12 of your record book. For most questions you have to choose the best answer from the several answers suggested. In each of these cases, write only the letter of the answer which you choose.

You may assume that all the cells, globes and other electric components mentioned in the questions are like the ones you have used and are in perfect working order.

Questions 1–7

Name the parts numbered in the circuit at right.
Use words from the following list.

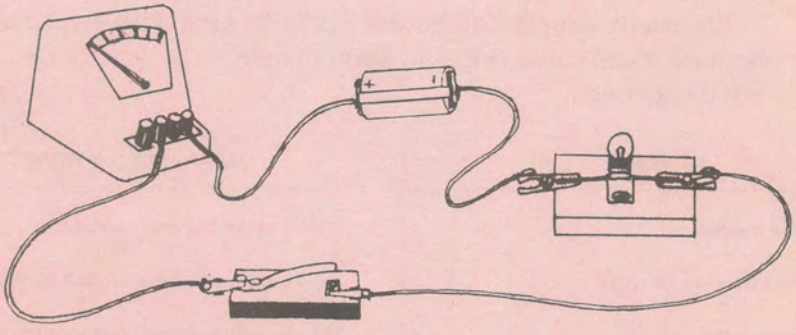
fuse
globe
battery
cell
contact
conductor
switch (open)
switch (closed)
junction of conductors
ammeter



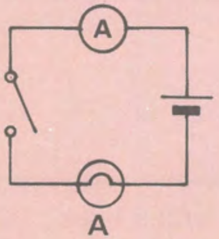
Check your answers from page 2 before going on.

---

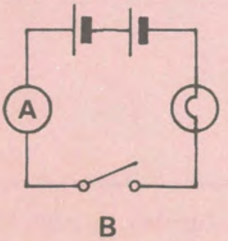
8 Here is a drawing of an electric circuit.



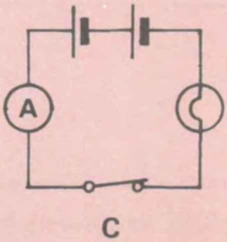
Which diagram below represents the circuit?



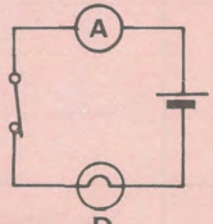
A



B

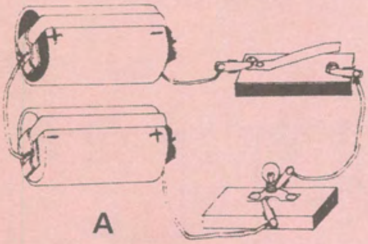


C

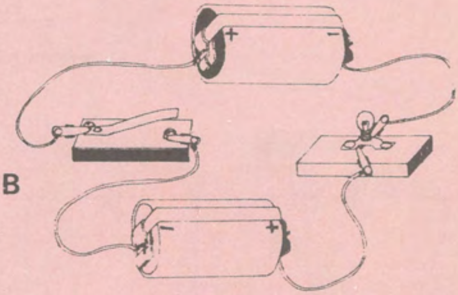


D

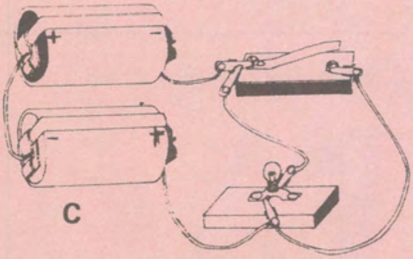
9 Three of the four circuits shown below work in the same way—the only difference between them is the way in which the components are arranged. But one circuit works differently from the others. Which circuit is this?



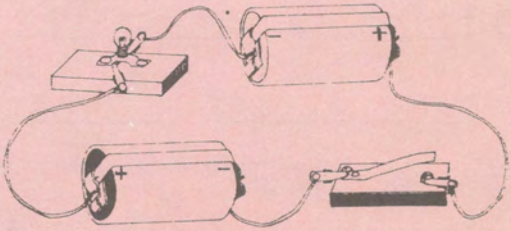
A



B



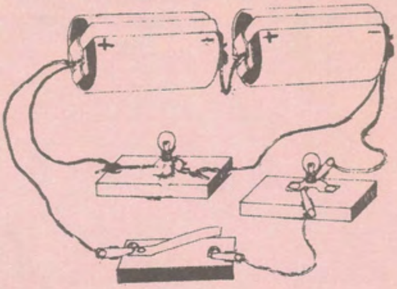
C



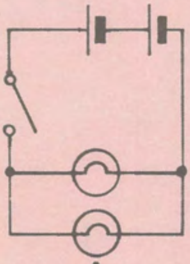
D

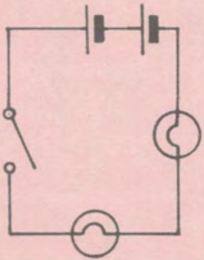
Test Yourself continued next page

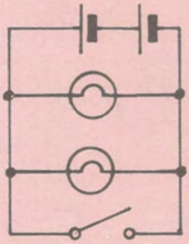
10 Here is a drawing of an electric circuit.

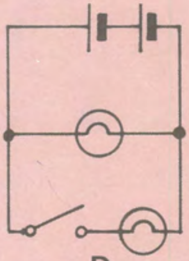


Which diagram below represents the circuit?


A


B


C


D

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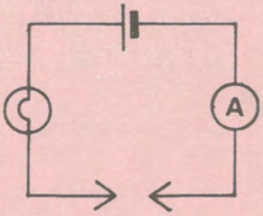
11 An object was placed between the contacts in the electric circuit shown in the diagram below.



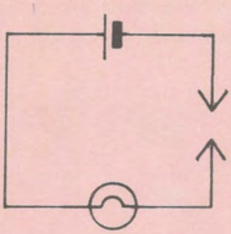
The ammeter needle moved slightly, but the globe did not light up. It is therefore true to say that the current was

A detected and was strong.

B detected and was weak.

C not detected.

12 Three objects—a high-resistance conductor, an insulator, and a low-resistance conductor—are placed in turn between the contacts in the circuit below.



Which would conduct the most current?

- A The high-resistance conductor
- B The insulator
- C The low-resistance conductor

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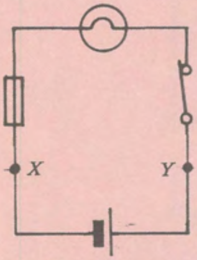
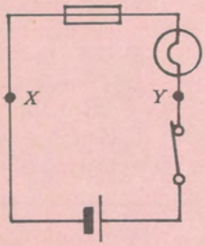
13 Below are four circuits. If each is shorted across XY, which one is most likely to have a blown fuse?



A



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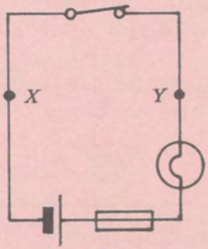

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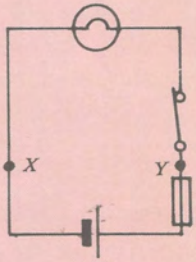
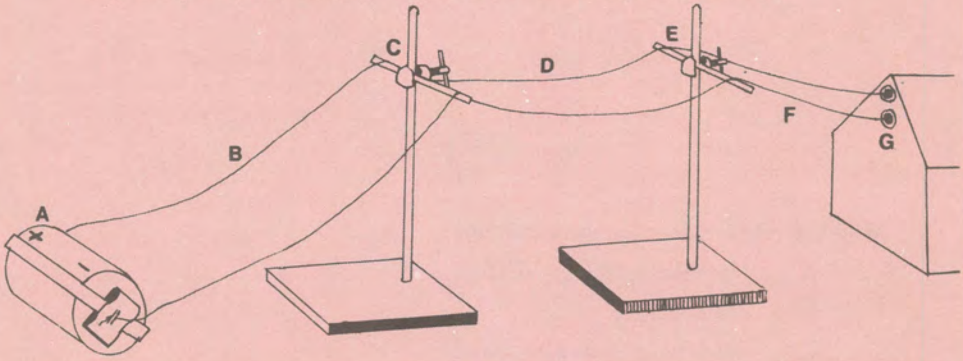


D

Test Yourself continued next page

14 Some students using metal supports and bare wire built a model of the power supply to a house. It wouldn't work because of 'short circuits'. Examine the diagram below of the model, and state where the short circuits would most likely be. (Write one or more of the letters A–G as your answer.)



15

BODY OF MAN FOUND IN ROOF

Parramatta–Wed. The body of a man was found yesterday afternoon in the roof of an old colonial-style house. The man was later identified as Samuel Sparky, 33, occupier of the house. Neighbours had noticed two days' milk standing on Mr Sparky's doorstep. They called the police, who later found the body. The police said it looked as if Mr Sparky had been electrocuted.

Which one of the following statements referring to the situation described above is true?

The man could not have been electrocuted if

A the insulation on the wires in the roof was in good condition.

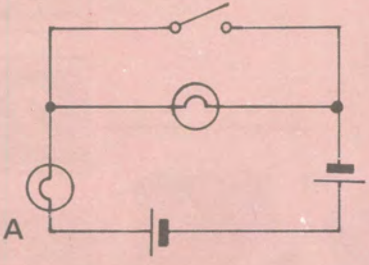
B he was wearing thick gloves and shoes.

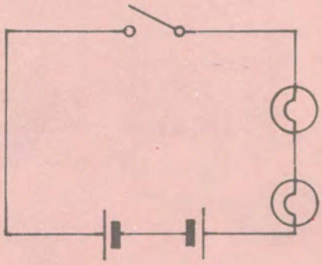
C the mains switch was in the off position.

D there were fuses of the correct thickness and these fuses were properly installed.

Questions 16–19

Look at the five different electric circuits below and use them to answer questions 16–19.


A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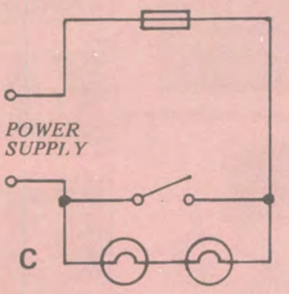
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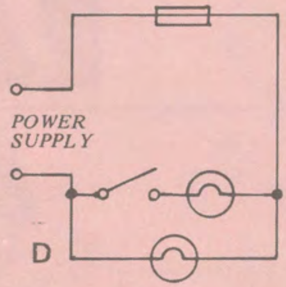
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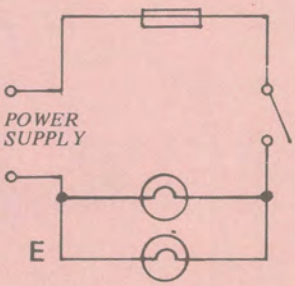

E

16 In which circuit or circuits are there two globes alight when the switch is open?

17 In which circuit or circuits are there two globes alight when the switch is closed?

18 In which circuit is the fuse most likely to blow when the switch is closed?

19 In one circuit nothing happens when the switch is closed. Which circuit?

Questions 20 and 21

Here are two harder problems. If you cannot solve them, do not worry. It is more important that you should have a go, than that you should worry about not being able to solve them.

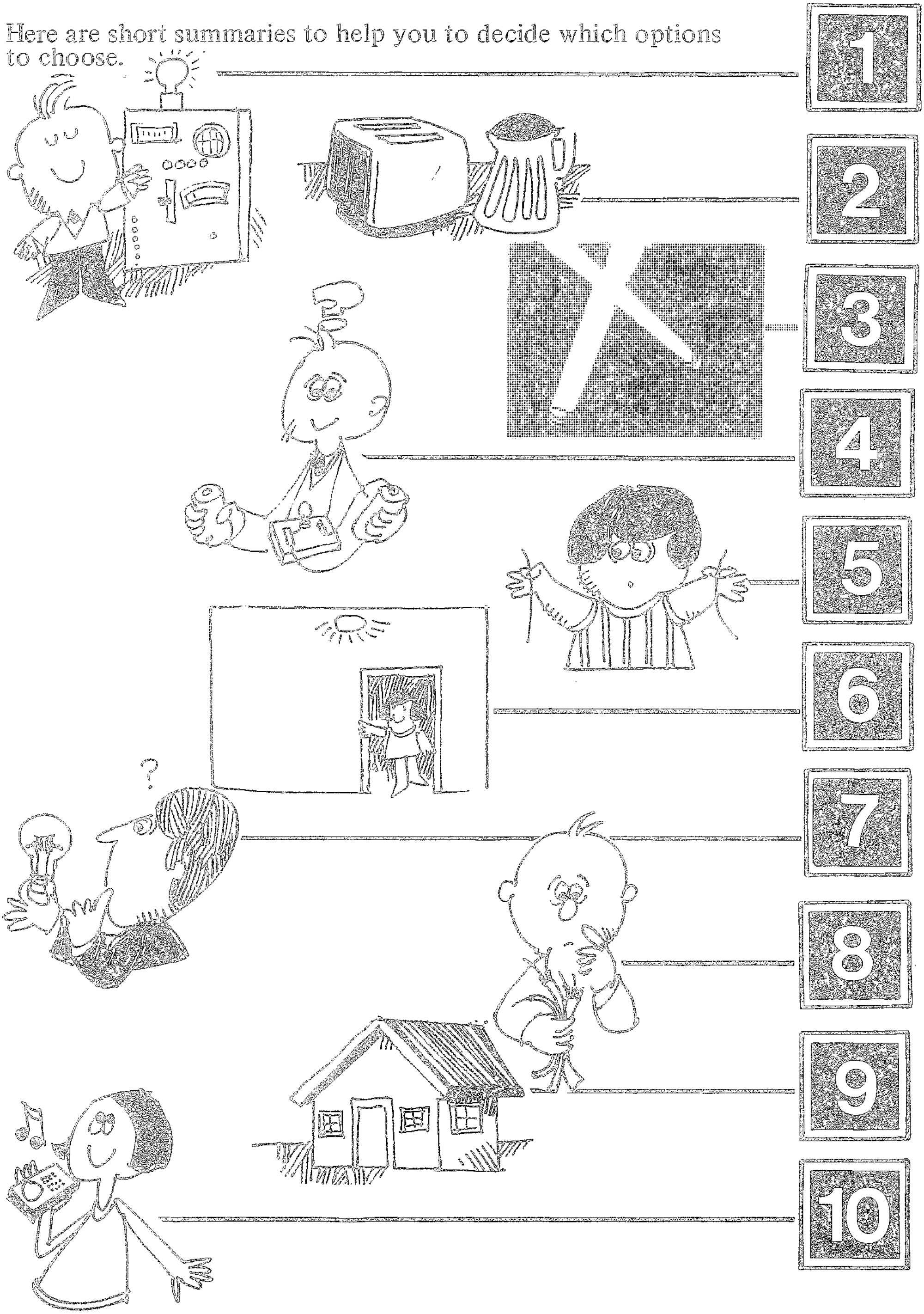
20 Design a circuit with one cell, one switch and one globe, so that the light goes **off** when the switch is closed. Draw the circuit diagram in your record book, page 12.

21 Design a circuit with one cell, two switches and a globe so that the light comes on when either one of the switches is closed, or both are. Draw the circuit diagram in your record book, page 12.
This circuit could be used to light the inside of a car which has two doors. The light is switched on when either of the doors is open.

Now turn to Check Your Answers on page 96 of this book.

ABOUT THE OPTIONS

Here are short summaries to help you to decide which options to choose.



YOUR INVENTION	You've found out enough about cells to try to invent something that uses cells to make it work. There are seven suggestions for inventions in this option. (Page 38)	1
HOT STUFF	Electricity can give heat and light. In this option you look at some ways we use heat. See how electric jugs and toasters work—then make an electric jug. (Page 43)	2
A CARBON ARC	Very bright lights in searchlights and movie projectors are called arc-lights. This option describes how you can make an electric arc. (Page 48)	3
MORE CELLS	Does the brightness of a globe depend on the number of cells in the circuit? What makes one cell last longer than another? Here you can find out. (Page 50)	4
THE LONG AND THE SHORT OF IT	Does the brightness of a globe change when you use longer or thicker connecting wires, or when you use different kinds of wire? (Page 56)	5
PARALLEL CIRCUITS	In this option, you find how to connect two globes so that you can switch on one, or the other, or both. This helps you understand how a room is wired. (Page 60)	6
INVESTIGATING A LIGHT GLOBE	Is there any gas inside a light globe? Why is the glass there? Perhaps you could make a light globe yourself. (Page 64)	7
ONE, TWO, THREE WIRES	A complete circuit is needed for electric current to flow. Things other than wire can complete circuits. (Page 71)	8
WIRES IN THE WALL	With the equipment you have used in Simple Circuits, you could wire part of a 'model house'. This option shows you the way. (Page 76)	9
MAKING A RADIO	Most radios look fairly complicated. However, you can make a radio that works from only simple equipment. (Page 80)	10

OPTION 1

You've found out enough about cells to try to invent something that uses cells to make it work. There are seven suggestions for inventions in this option.

Your Invention

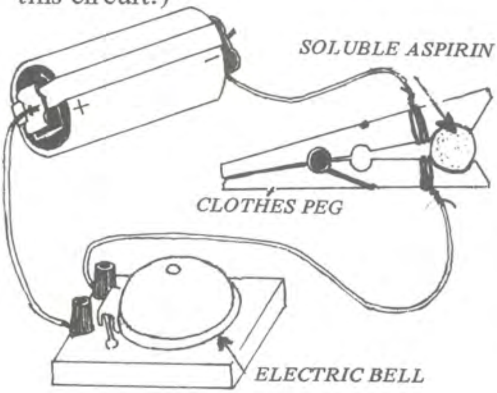
You could invent a light for a locker, or a torch. Or a quiz board with a light which comes on when someone picks the right answer to a question. You could play noughts and crosses by pressing switches.

It's a good idea to draw a sketch of your design before you start. Try to draw a circuit diagram, too. Make a list of all the things you think you will need to make your invention. If you also make a note of your problems and successes, you will be able to give a good report of your invention to the class.

There is space on pages 13–15 of your record book for notes and diagrams. You can try one or more of the ideas on this and the following pages, or perhaps you prefer to do your own inventing.

RAIN ALARM

Put the clothes peg outside. When enough rain falls, the aspirin dissolves, letting the clothes peg close and completing the circuit. (Some students at a school in England invented this circuit.)

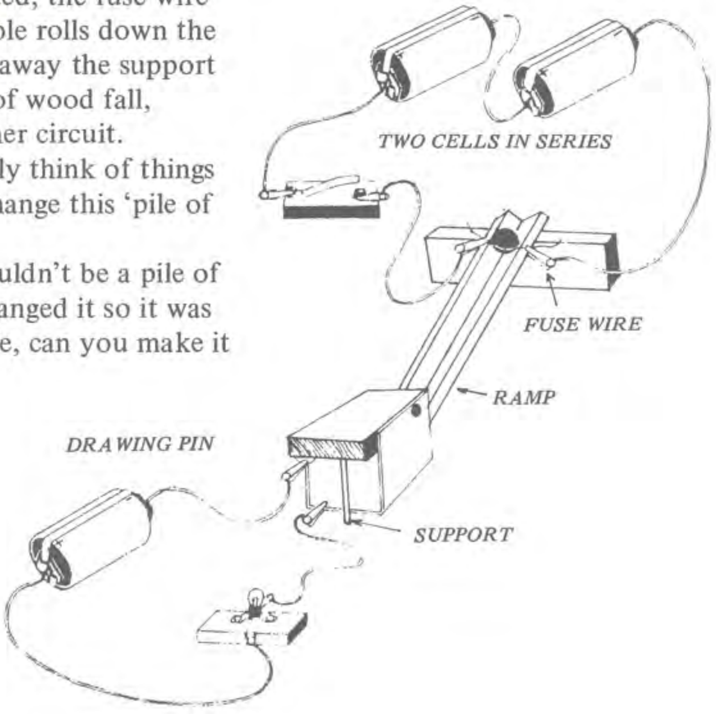


A PILE OF NONSENSE

When the circuit at the top of the diagram is completed, the fuse wire melts and the marble rolls down the ramp. This pushes away the support and lets the piece of wood fall, completing the other circuit.

You can probably think of things to add to and to change this 'pile of nonsense'.

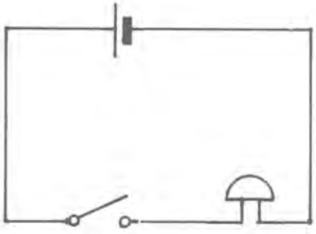
Of course, it wouldn't be a pile of nonsense if you changed it so it was useful. For example, can you make it into a fire-alarm?



BURGLAR ALARM

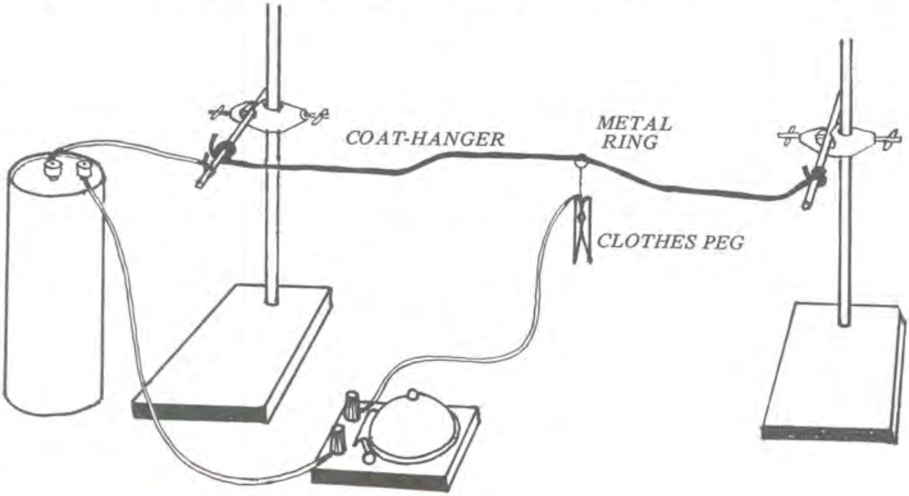
If you try this, you will have to design the switch yourself. If it is going to be an alarm, it will have to guard something such as a door or a window. To do this, your switch will have to close when the door or window is opened.

You could use your switch so that the alarm told you when someone was approaching, or opening, your locker!

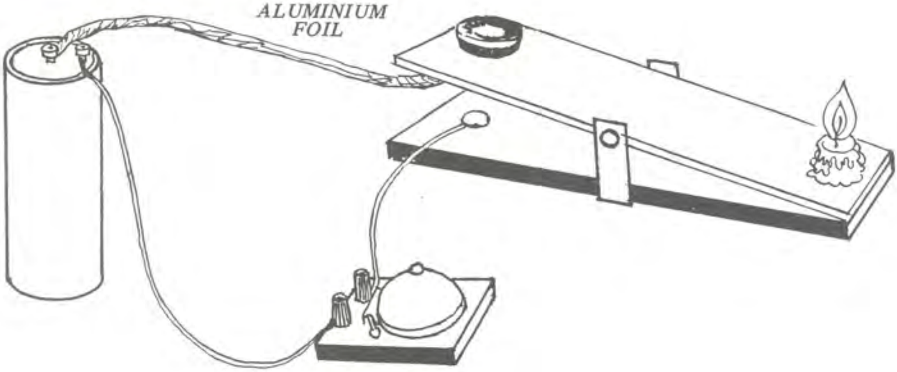


'TRY YOUR SKILL'

Have a competition to find who can move the ring along the coat-hanger wire in the shortest time without making the bell ring.



ALARM CLOCK



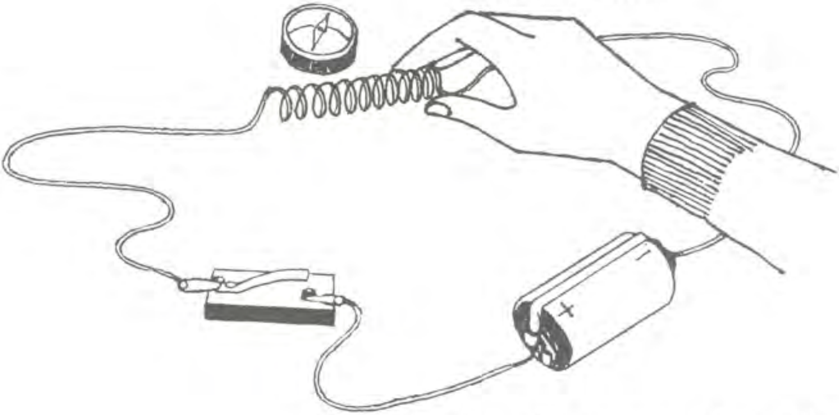
A COMPASS-NEEDLE DEFLECTOR

1

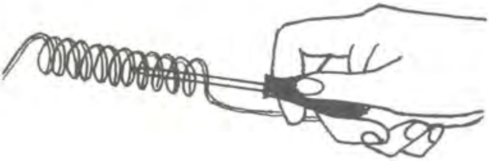
Wind about 1 metre of connecting wire around a test-tube to form a coil. Remove the test-tube.

Connect the coil to a cell and a switch. Place a magnetic compass next to the coil.

Close the switch.



Keep the compass where it is, and turn the coil over.

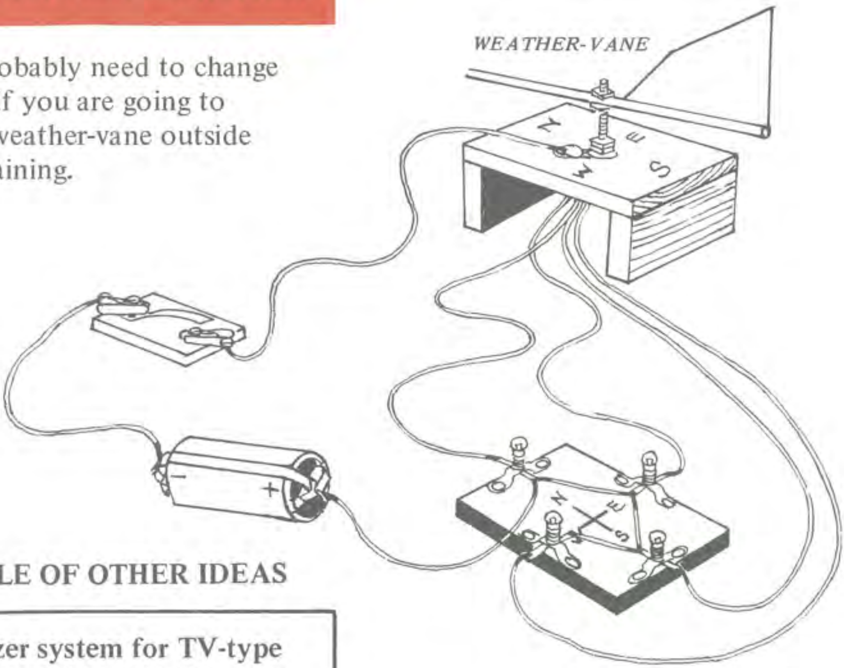


Keeping the switch closed, insert a pencil or a ball-point pen, then a screwdriver blade, into the coil. Notice what happens to the needle.

Try to think of something for which you could use a circuit like this.

WIND-DIRECTION INDICATOR

You'll probably need to change this a little if you are going to leave your weather-vane outside when it is raining.



A COUPLE OF OTHER IDEAS

☐ **A buzzer system for TV-type quiz shows.** (This could be quite complicated. How could you stop Contestant A's buzzer from sounding after Contestant B's button had been pressed?)

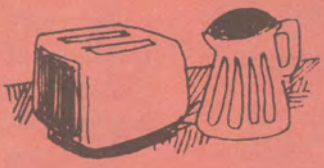
☐ **A two-way switch.** Some stairs, passages and rooms have two switches so that you can turn a light on as you enter from one end and off as you leave from the other end. Either switch can turn the lights on or off. See if you can invent a circuit to do this.

☐ **There are other interesting ideas in these books:**

Bender, A. *Let's Explore with the Electron.* New York, Sentinel, 1960.

Nuffield Junior Science. *Apparatus: a Source Book of Information and Ideas.* London, Collins, 1967.

OPTION 2



Electricity can give both heat and light. In this option you look at some of the ways we use heat. See how electric toasters and jugs work–then make your own electric jug.

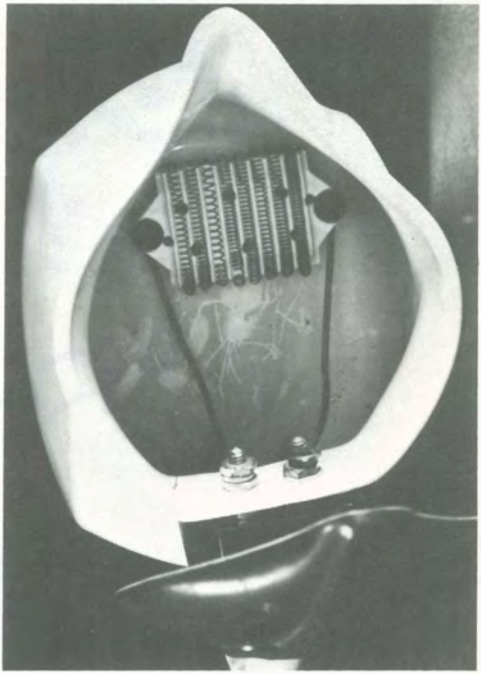
Hot Stuff

ACTIVITY 1: LOOKING AT ELEMENTS

You will need:

- 1 pair of pliers (or spanner)
- old heating appliances, e.g. iron, jug, toaster, radiator.

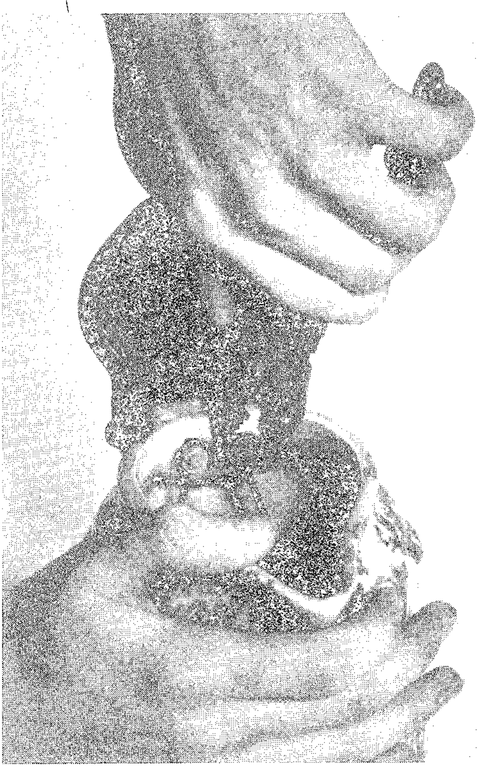
WARNING: Before you begin to examine an appliance, make sure it is not plugged into a power point.



The photo at right was taken looking down into an electric jug. The wire inside, which heats the water, is called the element.

If you have a jug, you can find out how it works.

Activity 1 continued next page



Carefully undo the nuts (as shown in the photo at left) and remove the element.

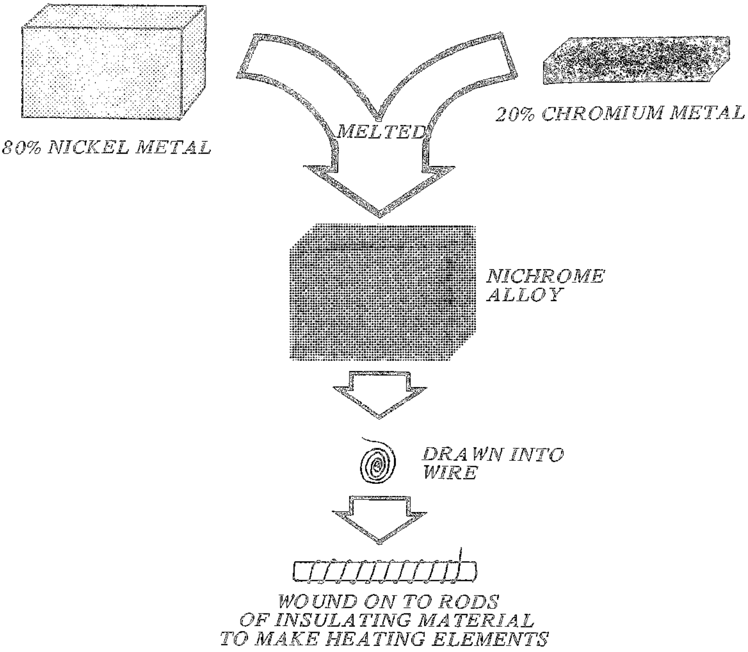
The elements of many electric heating appliances (jugs, radiators, irons, etc.) are coiled pieces of nichrome wire.

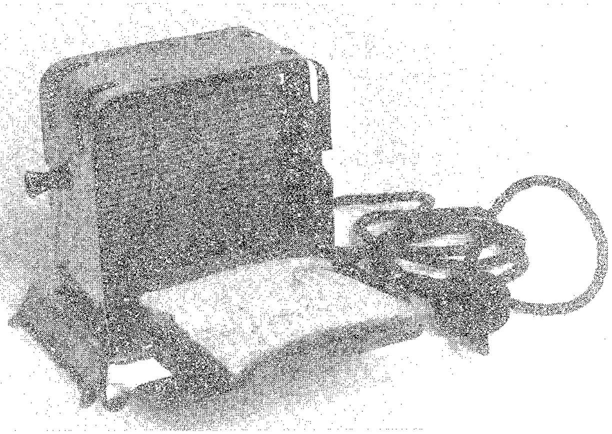
Nichrome is an alloy of nickel and chromium. An alloy is formed by melting two or more metals, mixing them while they are still molten (liquid), and allowing the mixture to cool.

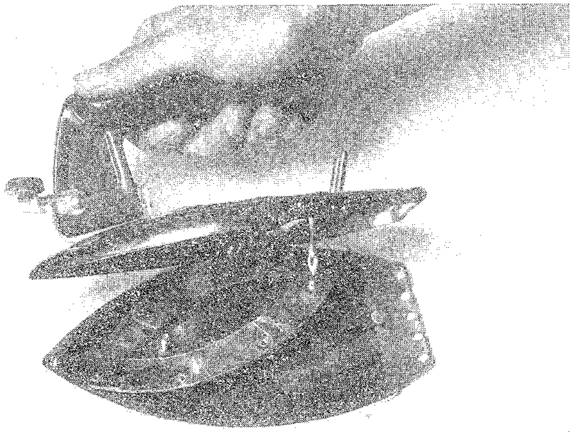
The process of making a nichrome wire element is shown below.

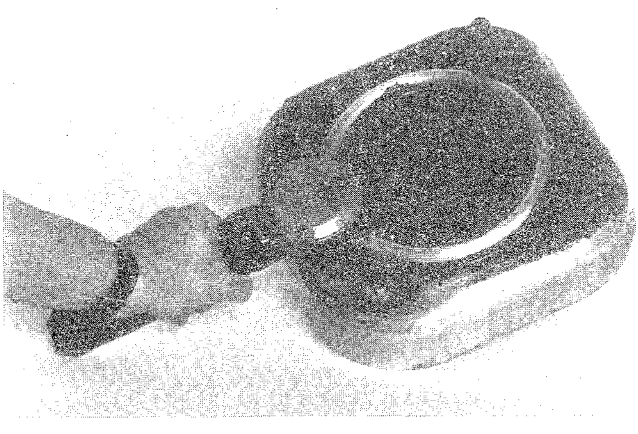
The elements of an electric toaster are made from nichrome wire wound around pieces of mica. Mica is an insulator.

You may have an old iron at home or at school. Examine it, making sure it is not plugged in. Or you may have an old hairdryer, or an electric kettle.





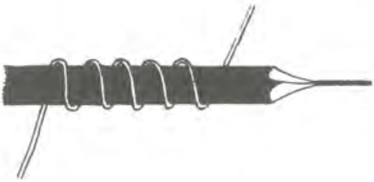


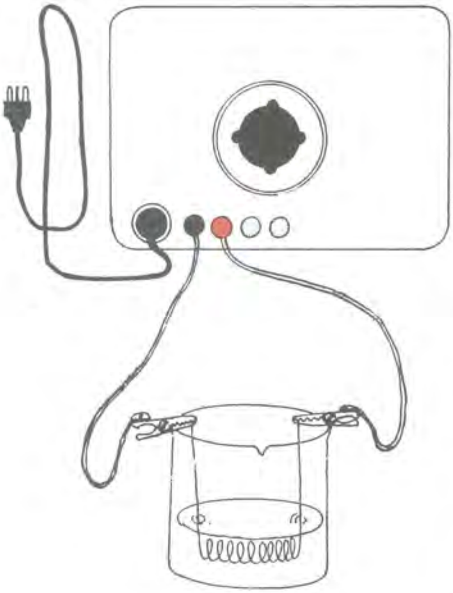


ACTIVITY 2: MAKE YOUR OWN ELECTRIC JUG

You will need:

- 1 power pack (or a car battery)
- 2 pieces of connecting wire
- 2 alligator clips
- 60 cm of thick nichrome wire
- 1 beaker, with water.





1 So that the nichrome wire will fit into your 'jug', coil the wire around a pencil (or ball-point pen) as shown at left. About 10 turns in the coil will be enough.

2 Connect ends of the wires to the red and black terminals of the power pack.

3 Slip your pencil out and connect this element into the circuit as shown at left.

4 Plug in, but **don't switch on yet**.

5 Ask a teacher to check your circuit before you switch on the power pack.

6 The teacher will tell you where to set the knob on the power pack.

7 Read through the list of other things to do at right. If you would like to try any of them while the jug is heating, collect the necessary extra equipment.

8 Switch the 'jug' on and leave it switched on for about five minutes.

9 Switch off and feel the water. Is your heater good enough to boil a cup of water in a short time?

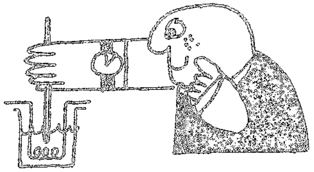
2.1 On page 16 of your record book, write a summary of your findings.

2.2 Why should the element in an electric jug always be covered with water while the jug is on?

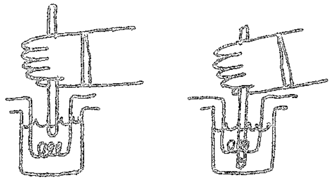
2.3 Why does an electric jug have a lid which cannot be opened when the lead is plugged in?

2.4 Why is the element of a jug coiled?

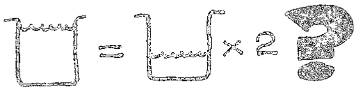
HERE ARE SOME THINGS YOU MAY LIKE TO DO WHILE YOUR 'JUG' IS HEATING.



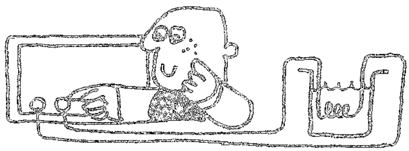
☐ Measure the water temperature every minute for, say, five minutes. Calculate the rise in temperature for each minute the 'jug' was on.



☐ After the 'jug' has been on for a couple of minutes, measure the temperature above and below the coil. If there is a difference, try to explain why.



☐ Measure a certain volume of water into the beaker. Find how long that volume of water takes to be heated to a certain temperature. Then see if double that volume takes twice as long to heat.



☐ See how long it takes to heat equal volumes of water to the same temperature when you set the power pack differently. (CAUTION: Always check with a teacher before adjusting the setting on the power pack.)

You can check your answers by turning to page 90 of this book.

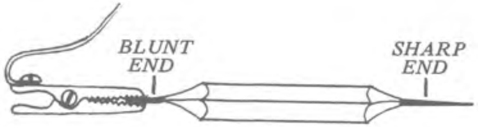
OPTION

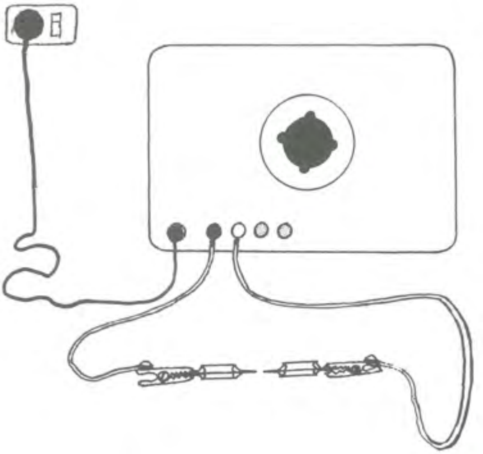
3

Very bright lights in searchlights or movie projectors are called arc-lights. This option describes how you can make an electric arc.

A Carbon Arc

The arc you will make is a very small one, and not dangerous. However, it may be wise to wear sun-glasses when you operate it because of its brightness.





You will need:
- 2 small pencils
- 2 pieces of connecting wire
- 1 power pack (or a car battery)
- 2 alligator clips.

1 Cut each pencil as shown at left. The sharp end must be very sharp. The lead at the blunt end must be long enough for an alligator clip to get a good grip.

2 Connect the wires from the pencils to the red and black terminals of the power pack.

3 Plug in the power pack.

4 Ask a teacher to check **before** you switch on.

5 Ask a teacher where to set the knob on the power pack.

6 Place the sharpened ends of the pencils close together, and close the switch. You should see a bright light. If you don't, move the pencils closer together.

WARNING: LEAVE THE ARC ON ONLY FOR A FEW SECONDS.

If you leave the arc on for more than 30 seconds, the wood of the pencils could become hot enough to catch fire.

It would also be dangerous to connect the pencils directly to a mains supply.

You will probably find that it is hard to hold the pencils the same distance apart for long.

Try to make a holder for the pencils so that you can adjust the gap between the sharpened points.

The conductors between which an arc forms are called **electrodes.**

You have been using pencil lead for electrodes. (What is called the 'lead' in pencils is really a mixture of graphite and clay. Graphite is a form of carbon.)

Once you have the pencils mounted in a holder and the carbon arc is working, try the following types of pencil lead:

☐ two HB pencils
☐ two 2B pencils
☐ two 4B pencils
☐ two 2H pencils.

Make sure that the 'lead' in all these pencils is the same thickness and about the same length.

You could try arcing with two rods from old cells. (Sharpen these with a pencil sharpener.)

3.1 Do any of the pencils (or rods) work better than any others? (Page 17 of your record book.)

3.2 Can you measure the gap needed between the electrodes for an arc to function well?

3.3 If you were able to measure the gap, describe how you did it—and give the width.

3.4 Is air an insulator? A conductor? Discuss this problem in a small group, and record your opinion.

3.5 Draw a diagram of your arc and label it, showing the electrodes and holder(s) that you designed.

You can check your answers by turning to page 91 of this book.

OPTION

4

Does the brightness of a globe depend on the number of cells in the circuit? What makes one cell last longer than another?

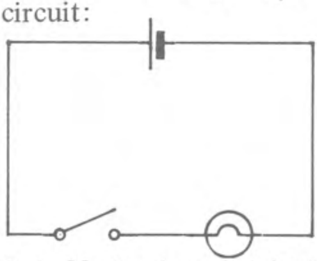
More Cells

ACTIVITY 1: THE MORE THE . . . ?

You will need:

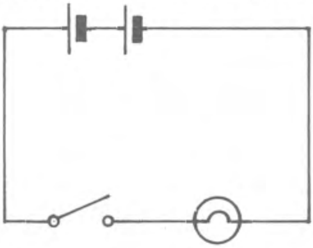
- 3 cells and 3 rubber bands
- one 6 V globe and holder
- 1 switch
- 5 pieces of connecting wire
- 3 drawing pins
- 1 paper-clip
- 1 block of wood about 5 cm x 5 cm x 1 cm
- 4 alligator clips
- 6 F-clips

Connect this circuit:



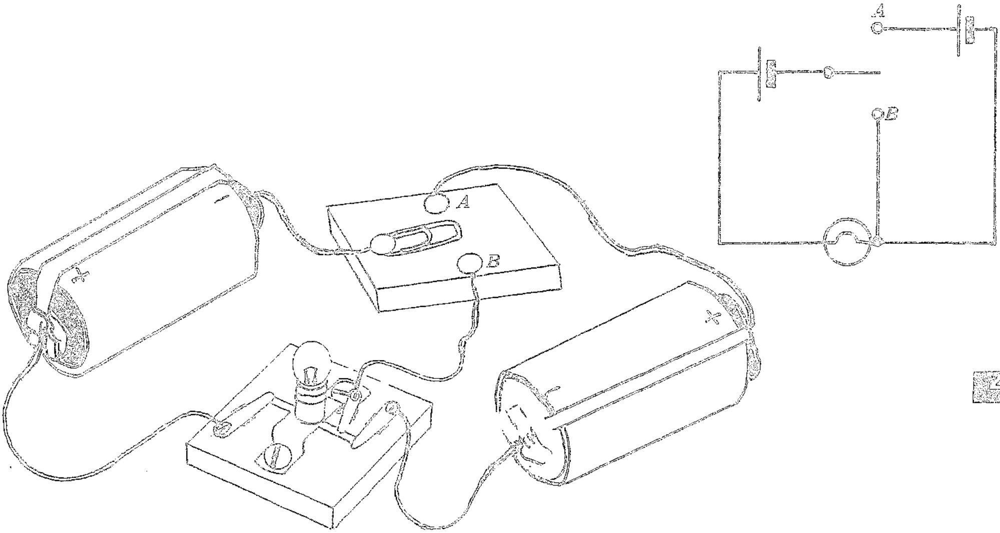
Close the switch. Notice how bright the globe is.

Now add another cell to the circuit by joining it like this:

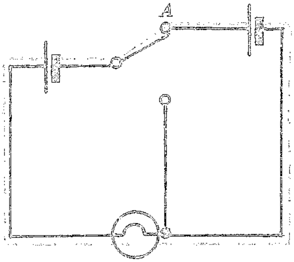


Cells joined end to end like this are in series.
Close the switch. Is the globe brighter now?

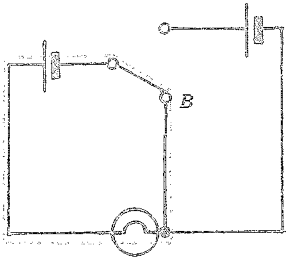
It would be easier to check on the brightness of the globe if you were working with a circuit like the one below. To set up this circuit, you need a two-way switch. You can make a two-way switch (like the one shown at the top of the diagram) from the block of wood, paper-clip and drawing pins.



When the paper-clip is turned to A (as below), two cells in series are in the circuit.



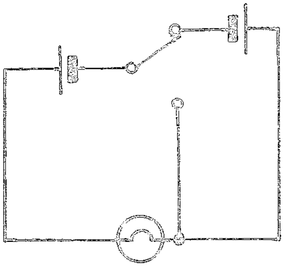
When the paper-clip is turned to B (as below), only one cell is in the circuit.



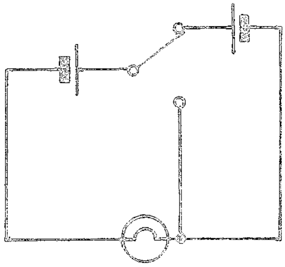
4.1 When is the globe brighter? (Page 18 of your record book.)

Activity 1 continued next page.

Join the other cell into the circuit like this:

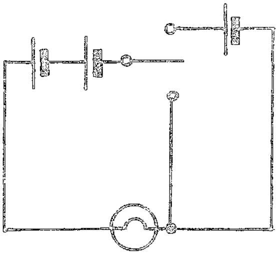


Now connect this circuit:



4.2 What happens to the globe in the two circuits above?

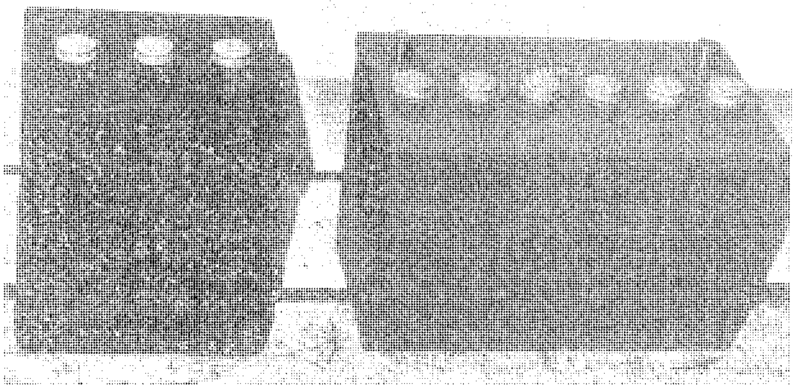
Try three cells like this:



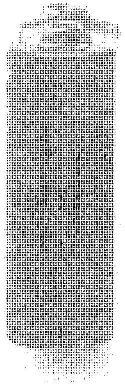
4.3 In your record book, write a summary of your observations. Make up a rule about what you think happens to a globe when cells are joined in series.

4.4 What would happen to the globe if you added many more cells?

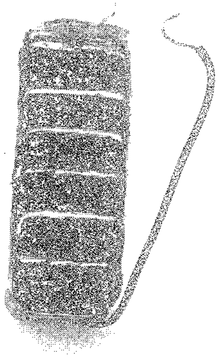
A number of cells in series is called a battery. A car battery usually has six cells in series, although some have three.



Transistor radio batteries consist of a number of cells. If you have a battery that has gone flat, you could saw it open with a hacksaw and examine the cells.

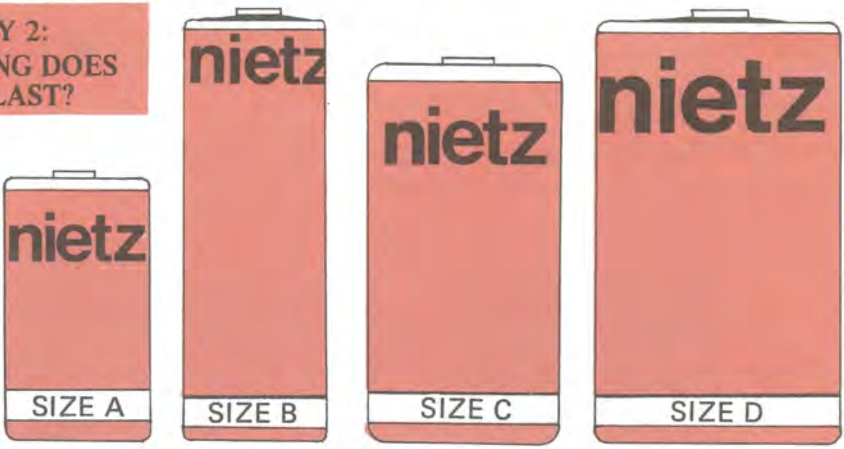


INTACT
BATTERY



BATTERY
SAWN
IN HALF

ACTIVITY 2: HOW LONG DOES A CELL LAST?



A plan for a test of
DIFFERENT SIZES OF CELLS

To find out which size lasts the longest, you will need to keep everything other than the size the same in each case. You will need to use:

☐ same type of globe,
☐ same circuit,
☐ same brand,
☐ same number of cells (only one), and
☐ same running conditions.

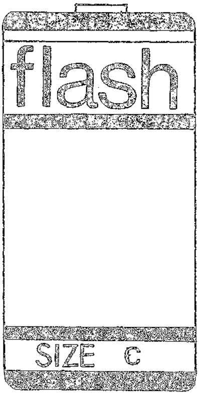
The things that are kept the same in tests like this are called **constants.**

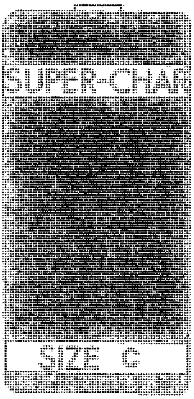
The thing you are changing is called the **variable.** In this test, the **size** of the cell is the **variable.**

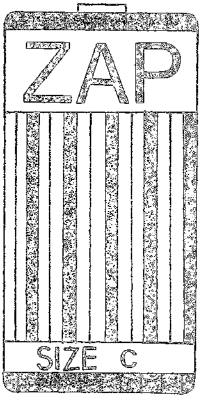
When you have checked the constants and variables, set up the test circuits. You are now ready to measure the length of time the cells keep the globes alight. Some cells may keep a globe alight for more than 100 hours.

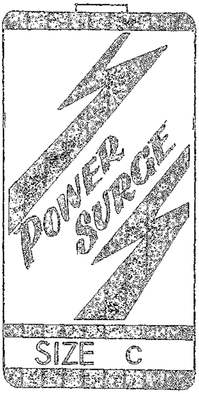
4.5 In the first table on page 19 of your record book, record the time you switch on each cell. Also record the time each cell stops lighting the globe.

4.6 Calculate the 'running time' in hours for each cell, and record this in the table, too.









A plan for a test of

DIFFERENT BRANDS OF CELLS

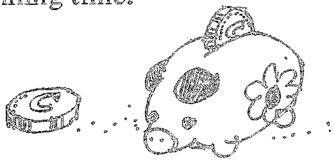
To find out which brand lasts the longest, you will need to keep everything other than the brand the same. You will need to use:

☐ same type of globe,
☐ same circuit,
☐ same size of cell (e.g. all size D or all size C),
☐ same number of cells (only one), and
☐ same running conditions.

4.7 In the other table on page 19 of your record book, record times started and stopped, and the running times.

OTHER THINGS TO DO

☐ Which cell gives best value for money? For each cell tested, work out the cost (in cents) for each hour of running time.



☐ Do two cells last twice as long as one? Set up two circuits to try to find out.

You can check your answers by turning to page 91 of this book.

OPTION 5

Does the brightness of a globe change when you use longer or thicker connecting wires, or when you use different kinds of wire?

The Long and the Short of It

ACTIVITY 1: THICK OR THIN?

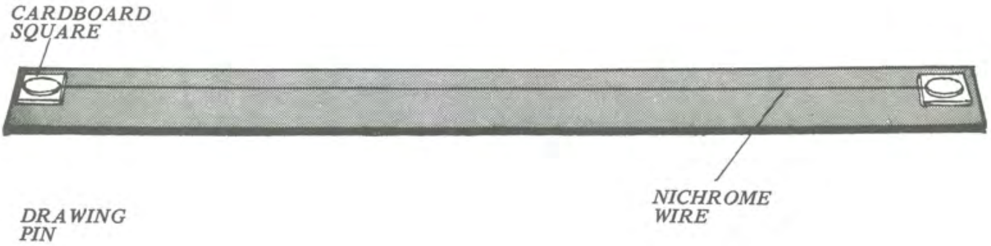
You will need:

- 1 metre of thin nichrome wire
- 2 metres of thick nichrome wire
- 1 cell, rubber band and F-clips
- 1 globe and globe holder
- 1 metre ruler
- 3 drawing pins
- 3 pieces of cardboard, each about 2 cm square
- 3 pieces of connecting wire
- 3 alligator clips.

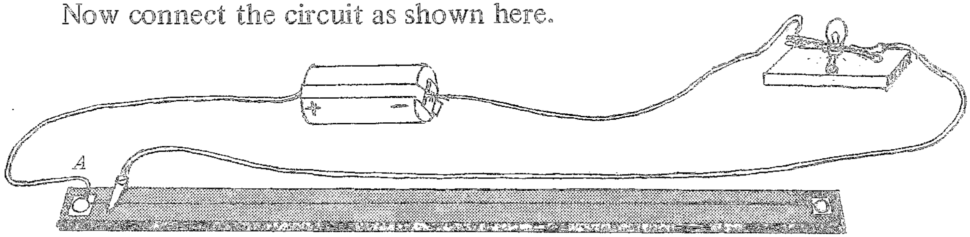
TESTING THE THIN WIRE

Push a drawing pin through a cardboard square into the metre ruler, close to one end.

Do the same at the other end and stretch some thin nichrome wire between the drawing pins.



Now connect the circuit as shown here.



Attach one of the alligator clips to the wire about 2 centimetres away from A.

Move the alligator clip 5 centimetres from A, and notice if there is any change in the brightness of the globe.

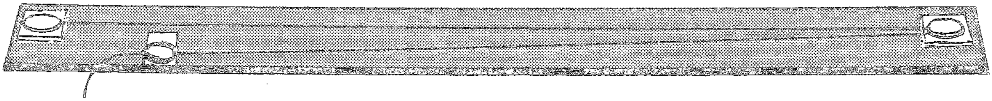
Now move the clip farther away from A until the globe goes out.

5.1 Measure this distance and write the measurement in your record book (page 20).

To check your results, put the alligator clip 5 centimetres from A, and move it along the wire again until the globe again goes out.

TESTING THE THICK WIRE

Now use the 2 metres of thick nichrome wire. Below is one way of fixing it on the metre ruler:



Connect the thick nichrome wire to the rest of the circuit.

Connect the alligator clip about 5 centimetres along from A. Move the clip along the wire until the globe goes out.

5.2 Measure this length and record the measurement. Repeat the measurement and record this result, too.

The brightness of the globe depends on the electric current flowing through it. The greater the current, the brighter the globe.

5.3 Compare the current flowing through the circuit when there are 5 centimetres of thin nichrome wire with the current when there are 30 centimetres of thin nichrome wire.

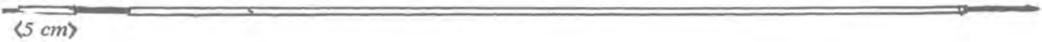
5.4 Compare the current flowing when there are 5 centimetres of thin nichrome wire with the current when there are 5 centimetres of thick nichrome wire in the circuit.

ACTIVITY 2:
HOW MUCH IS TOO MUCH?

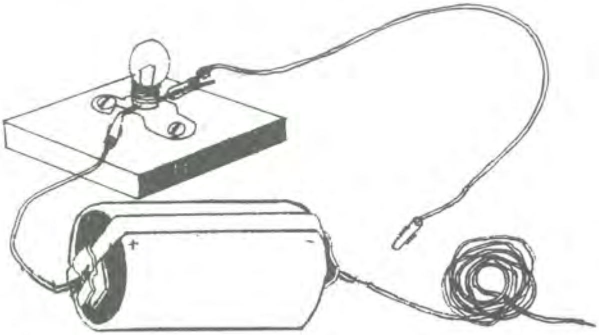
In this activity, you will be using copper wire instead of nichrome wire.

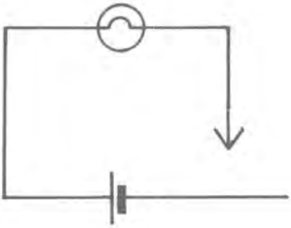
You will need:
- all the equipment from Activity 1, except the nichrome wire
- 1 metre of insulated copper wire
- 50 metres of insulated copper wire
- 1 pair of wire strippers (or a file)
- some large sheets of cardboard, scissors and adhesive tape.

Take the 1-metre length of copper wire, and remove the insulation from three places as shown below.



Then join up the circuit as shown in the diagram below.



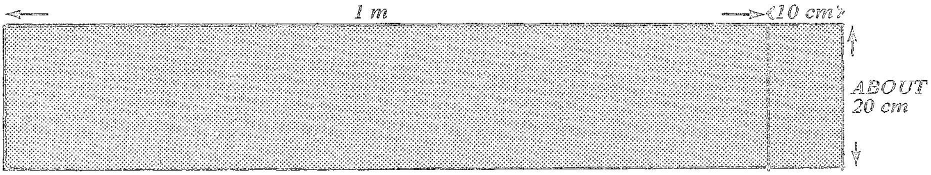


5.5 Is the globe brighter or dimmer when the alligator clip is at the 5-centimetre mark or at the end of the wire, or does there seem to be no change in brightness?

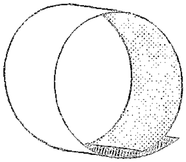
Remove the 1-metre length of copper wire from the circuit, and take the 50 metres. To begin, you will need to unwind about 25 metres of the wire. To save yourself from becoming entangled, make a spool to wind the wire around.

MAKING A SPOOL

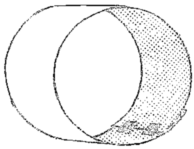
Cut out a piece of cardboard about 110 centimetres by about 20 centimetres. Mark a line across it 1 metre from one end.



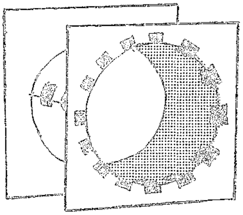
Roll the cardboard into a cylinder of circumference 1 metre.



Tape the ends together, both inside and outside the join.



Cut two sides for your spool and tape them on as shown below.



Wind 25 metres of the wire on to your spool as you unwind it from the roll. Count the turns. Each turn is 1 metre.

Connect the free end of the wire to the vacant F-clip on the cell.

At the 25-metre mark on the wire, strip a couple of centimetres of insulation, and attach the alligator clip to it.

5.6 Compare the brightness of the globe with its brightness when only 1 metre of copper wire was in the circuit.

Wind the remaining 25 metres on to the spool.

5.7 Test the effect of this extra length on the brightness of the globe, and record what you noticed.

5.8 Write a short report of what you found out about copper wire as a conductor.

5.9 Which of these would you use as connecting wire?

☐ Thin nichrome wire ☐ Thick nichrome wire ☐ Copper wire

Explain why in your report. (Before you try to explain, you may find it helpful to read pages 16 and 17 again.)

You can check your answers by turning to page 91 of this book.

OPTION

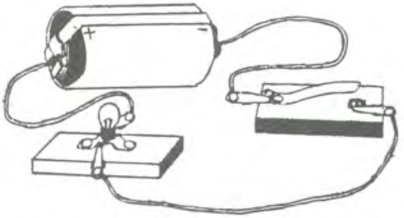
6

In this option, you can find how to connect globes so that you can switch on one, or the other, or both. This is important if you want to understand how a room is wired.

Parallel Circuits

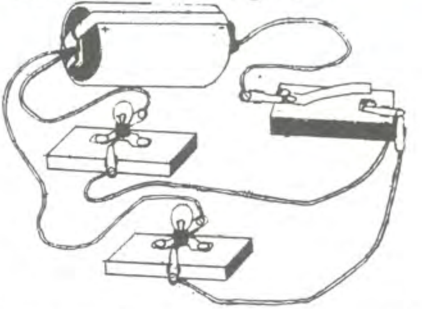
You will need:
- 1 cell
- 2 globes and globe holders
- 6 alligator clips
- 2 F-clips
- 1 rubber band
- 1 switch
- 5 pieces of connecting wire.

First, connect the circuit as shown in the diagram below.



This is a **series** connection.

Now add a second globe.



You now have a **parallel** connection.

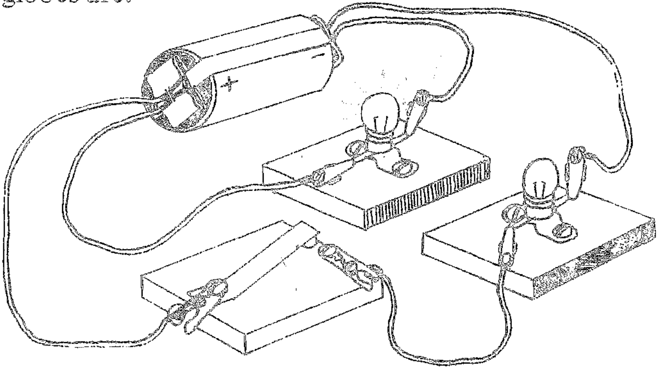
Try tracing the paths that the current will take when the switch in the parallel circuit is closed.

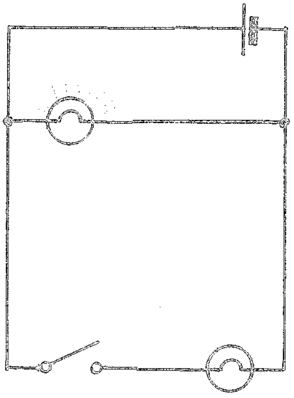
6.1 In the series circuit, there was only one possible path for the current. How many are there in the parallel circuit? (Page 22 of your record book.)

Take one globe out of its holder. Will the other one light up when the switch is closed? Try it.

6.2 Compare the brightness of the remaining globe with the brightness of each globe when both are in the circuit.

Here's a circuit which you can use to help you compare how bright the globes are.





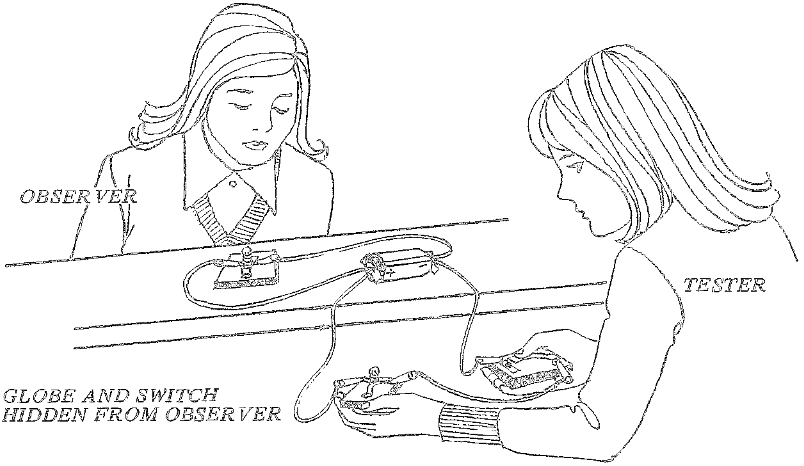
6.3 When the switch in the above circuit is open, how many globes are lit?

6.4 How many are lit when the switch is closed?

You can now compare the brightness of the two globes. Just close the switch to see if there is a difference. If you can get two long pieces of connecting wire, you could try a test as shown in the diagram below.

An observer won't know when the switch is closed. Work with another student doing this option and take turns at being observer and tester.

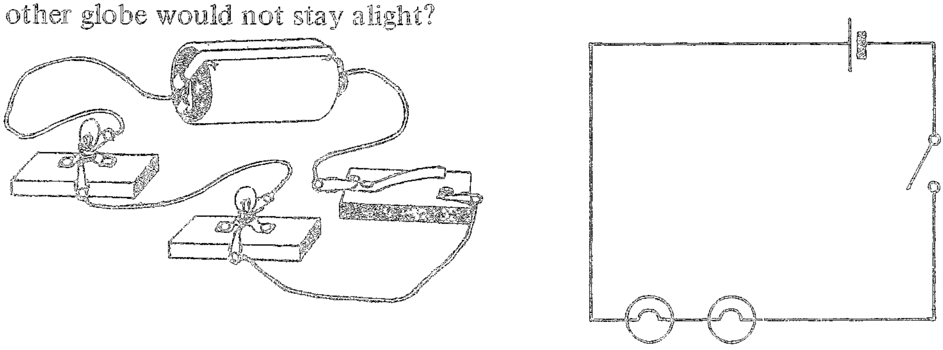
See how many times an observer can tell if the switch is closed in, say, ten tries. Make sure that the switch is closed silently.



6.5 How many times was the observer able to detect when the switch was opened and closed? After each try, record the results.

SERIES CIRCUITS

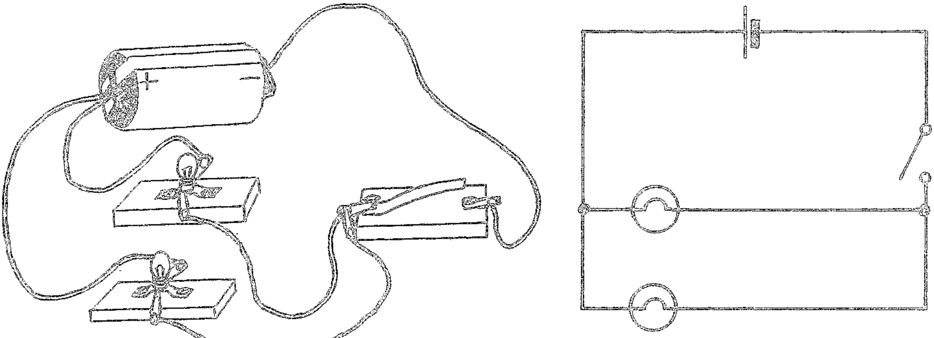
Connect the circuit shown in the diagram below. Close the switch, and see what happens when you unscrew one of the globes. Can you think why the other globe would not stay alight?



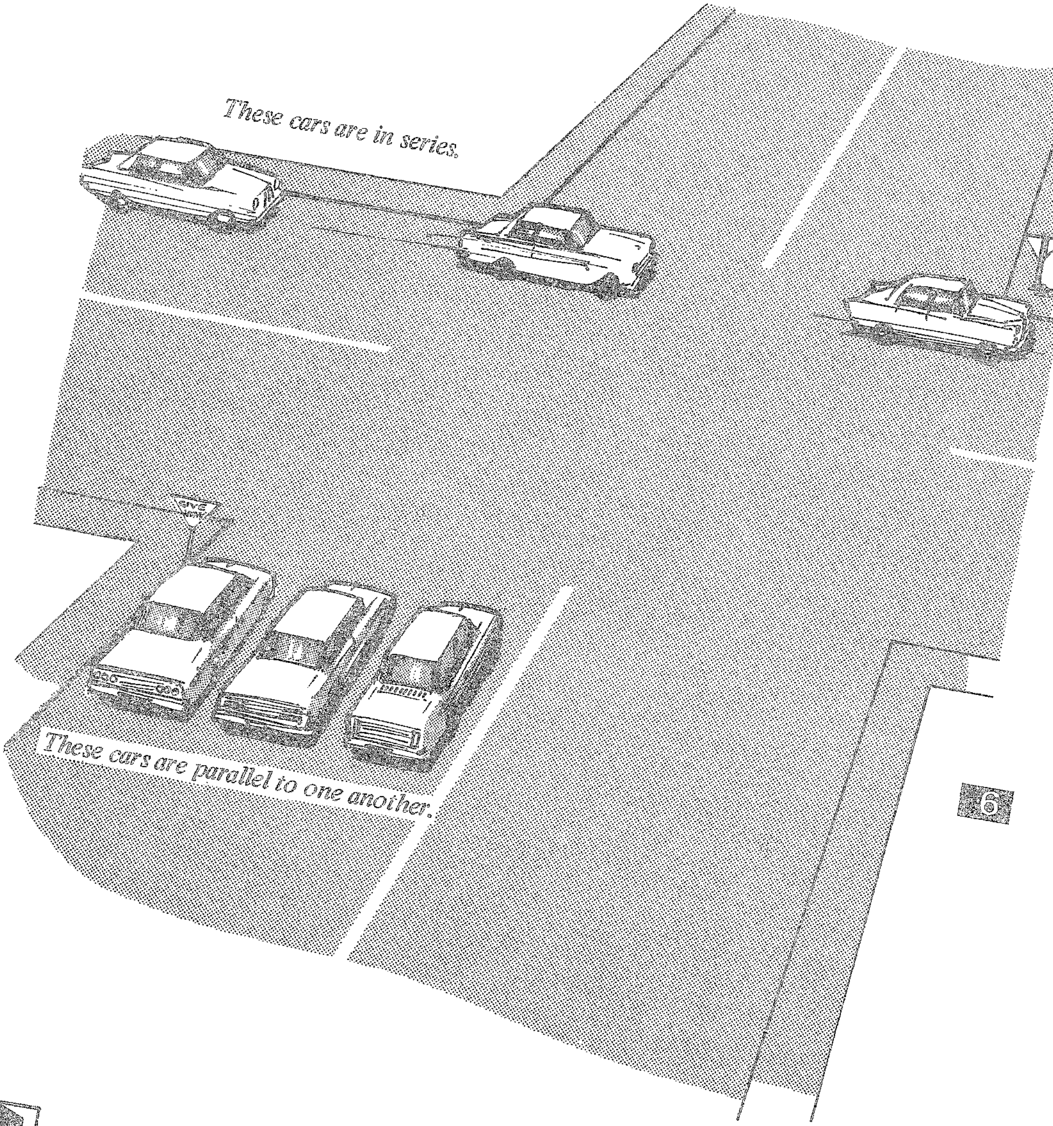
The globes in this circuit are in series.

PARALLEL CIRCUITS

Connect the next circuit, and again unscrew one of the globes.



The globes in this circuit are in parallel.


These cars are in series.
These cars are parallel to one another.

6.6 to 6.9 Turn to page 23 of your record book and look at Circuits A to D. Try to answer the questions about these circuits.

You can check your answers by turning to page 92 of this book.

OPTION

7

Is there any gas inside a light globe? Why is the glass there? Perhaps you could make a light globe yourself.

Investigating a Light Globe

Early humans used the light of fire to illuminate their caves.

Today, at the touch of a switch we can light our homes.

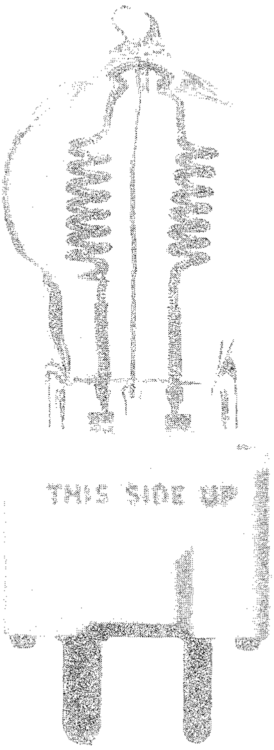
Many of these lights we use are fluorescent tubes. Others are globes, which glow from the light of a heated wire. These are called **incandescent** globes.

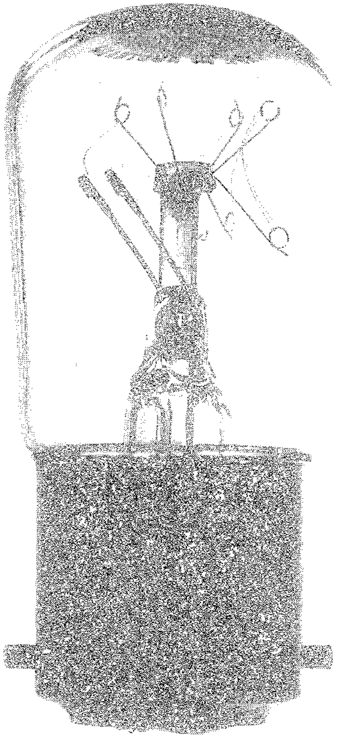
More than 76 million* incandescent globes and fluorescent tubes are manufactured in Australia each year.

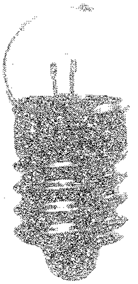
New York at night would look different from this if there were no electric lights.
(Photo by courtesy United Press International.)

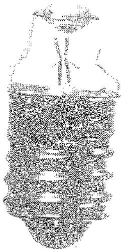
*** These are the figures for 1969–70 as supplied by the Commonwealth Bureau of Census and Statistics.**

There are many types of incandescent globes. Some are shown below.

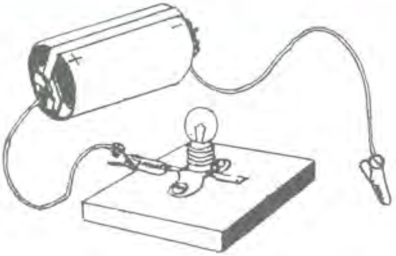


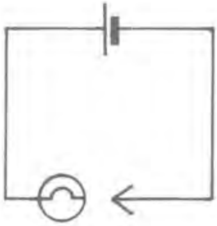


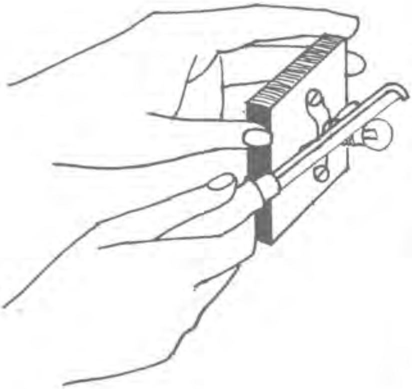




ACTIVITY 1:
A SHORT-LIVED FILAMENT







You will need:

- 1 cell, rubber band and F-clips
- 1 globe and holder
- 2 pieces of connecting wire
- 2 alligator clips
- 1 glass-cutting knife (or small triangular file).

Screw the globe into the holder.

Set up the circuit as shown at left. Make sure that one of the alligator clips is **not** connected to the globe holder.

Holding the globe holder carefully, file along the line which separates the glass of the globe from the brass.

File until you have a small hole in the globe. Air can now enter the globe.

When you are ready, complete the circuit.

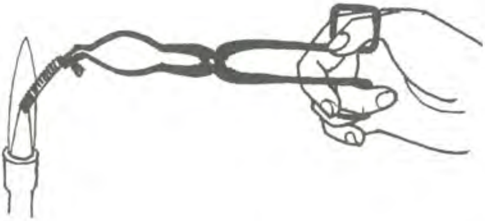
7.1 Describe what you saw happen to the globe, and what it looked like afterwards. (Page 24 of your record book.)

You probably noticed a creamy powder on the inside of the glass. This is the chemical tungsten oxide. The filament in an ordinary light globe is made of **tungsten**. When you let air into the globe, the tungsten filament burnt away to form tungsten oxide.

$$\text{tungsten} \xrightarrow[\text{in air}]{\text{when burnt}} \text{tungsten oxide}$$

Tungsten is a metal. You could find out how other metals are affected by being heated in air. Magnesium is a good one to try.

ACTIVITY 2:
BURNING A METAL IN AIR



magnesium $\xrightarrow[\text{in air}]{\text{when burnt}}$ magnesium oxide

You will need:

- 1 burner
- matches to light the burner
- 1 small piece of magnesium ribbon, less than 5 cm–any longer than this could be dangerous
- 1 pair of tongs (or pliers) to hold the magnesium
- 1 mat to protect working area
- 1 pair of sun-glasses.

Put on the sun-glasses. Hold the ribbon in the tongs at the tip of the blue flame.

WARNING: The light from burning magnesium can damage your eyes. To protect your eyes, look away as soon as the magnesium starts to burn.

When the magnesium starts to burn, look away, and put the burning ribbon on the mat.

7.2 How much of the magnesium burned?

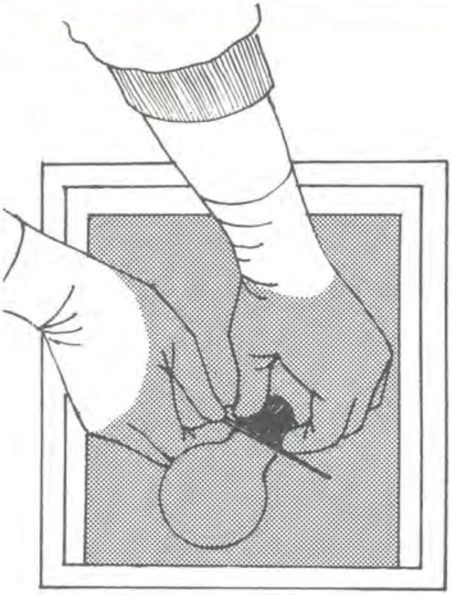
7.3 Describe what was left when the burning stopped.

If you want to heat a metal until it glows, yet keep it from burning, the air must be kept away from it.

Most globes are designed so that their filaments will not burn.

So what is in a light globe? Perhaps there is no gas at all. The next activity will help you to find out.

ACTIVITY 3:
IS THERE ANY GAS INSIDE A GLOBE?



To try to find the answer to this question, you will need:

- 1 household globe–a 'blown' globe will do
- 1 glass-cutting knife (or small triangular file)
- 1 large container of water.

Put the globe under water and hold it by the brass cap. File gently along the line between the glass and the brass until you have a small hole in the glass. Watch the globe as you file.

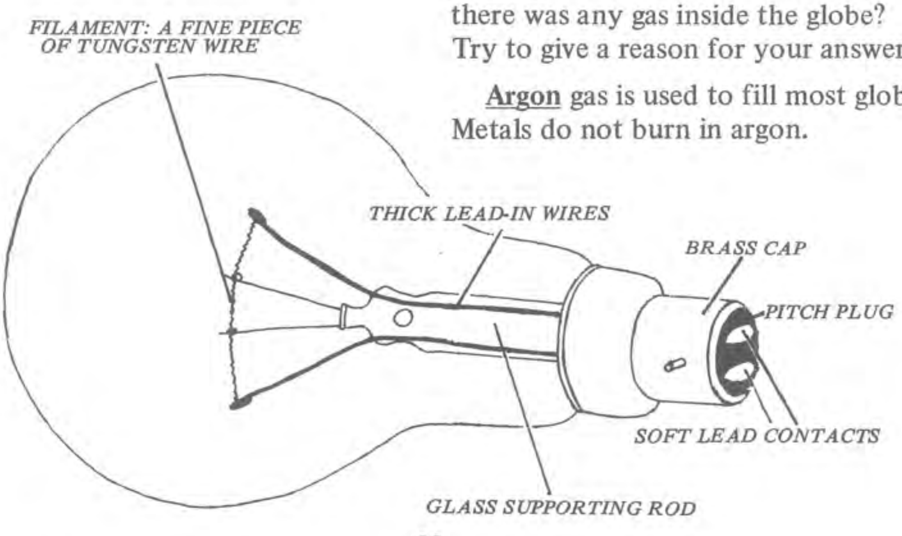
WARNING: Wear protective gloves if available. If you accidentally break a globe, collect all the pieces of glass and put them in a bin for broken glass. If you cut yourself, have the cut treated promptly.

7.4 Did any bubbles come out of the globe? If so, how many?

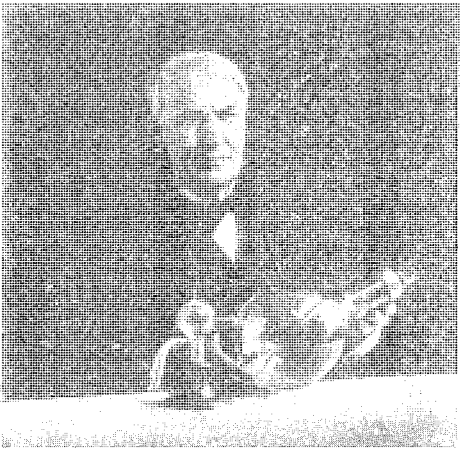
7.5 Did any water go inside the globe? If so, how much?

7.6 Do you think that there was any gas inside the globe? Try to give a reason for your answer.

Argon gas is used to fill most globes. Metals do not burn in argon.



THOMAS EDISON, INVENTOR



Thomas Edison with his original electric light globe and a later, improved version.
(Photo by courtesy of Brown Brothers, Philadelphia, USA.)

From 1800 onward people in England and the USA, and in many other countries, tried to use electric current to obtain light.

The American inventor Thomas Edison (1847–1931) tried hundreds of different filaments. He put them inside glass bulbs, and pumped out all the air to prevent the filament burning. In 1879, he used some carbon filaments made from thick paper. These lasted for hundreds of hours.

Edison devised nearly a thousand inventions, mainly concerned with electricity. If you would like to find out more about him, you could look for suitable books in a library. Some are listed below.

Encyclopaedia Britannica. Chicago, Benton, 1971, vol. 7.

Gordon, S. *A Pageant of Scientists, Book 2: Thomas Alva Edison—His Life, Work and Experiments.* Oxford, Blackwell. [n.d.]

Guthridge, S. *Tom Edison: boy inventor.* Indianapolis, Bobbs Merrill, 1959.

Merit Students Encyclopedia. New York, Crowell-Collier, 1973.

Nuffield Junior Science. *Apparatus: a Source Book of Information and Ideas.* London, Collins, 1967.

The World Book Encyclopedia. Chicago, Field, 1971, vol. 6.

Old-Fashioned Beacon

THOMAS ALVA EDISON invented the electric light bulb in 1879. Twenty-two years later, in 1901, one of the newfangled gadgets was hung and turned on in the Livermore, California, Fire Department. It's still there, and still on. The old bulb has been turned off almost never in 71 years.

By today's standards it should have burned out 852 times by now. The bulb, hand-blown, with a thick carbon filament, was made, it is said, by the Shelby Electric Company, which did not become one of the giants of the industry, for an obvious reason. The Shelby Company made light bulbs to last, and nobody ever re-ordered.

The bulb is accorded an awesome respect by Fire Captain Kirby Slate and his men. In a time of planned and unplanned obsolescence, when gadgets are for ever falling apart or burning out or breaking up, it's reassuring to watch a dusty 71-year-old light bulb shine on and on and on.

—Charles Kuralt on CBS News

Reprinted with permission from Reader's Digest, *September, 1972, pages 8–9.*

SOME OTHER THINGS TO DO

As you do any of these things, you could record what you find out and later make a report of your work. If you would like to read more about light globes, you could look at some encyclopaedias or other books in a library. For a start you could use a dictionary and some books about chemistry to find the answers to these questions:

☐ What are the two main gases in air?

☐ What gas in the air causes a hot tungsten filament to burn and form tungsten oxide?

☐ What does **inert** mean?

☐ What is an inert gas?

MAKING AN INCANDESCENT GLOBE

To get a really bright light, you need to heat the filament white hot without melting it, breaking it or burning it. In most of the globes made more than 100 years ago, the filaments didn't last very long.

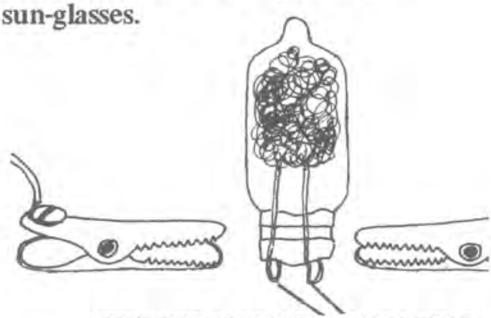
The best way to find out about this problem is to try to make a light globe yourself.

If you can use a power pack instead of cells, it will be easier to make filaments glow, but will still be safe. You could have a competition with another student to see who could get a filament to glow the brightest without burning out.

FLASH BULBS

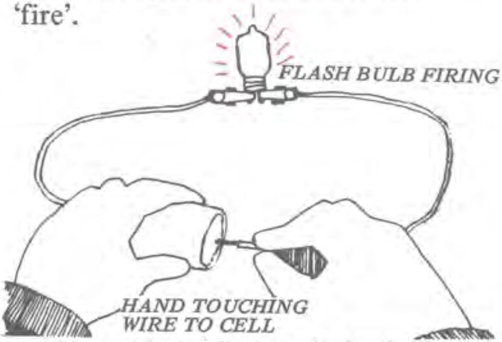
Do you know how to 'fire' a flash bulb without a camera? It's easy. You need only a cell and two pieces of connecting wire (with alligator clips attached)–and, of course, a flash bulb.

It would be wise if you wore sun-glasses.



CONNECT ALLIGATOR CLIPS HERE

Look at the flash bulb. You will find two contacts on the bulb. If you put these contacts in a circuit and close the circuit, electric current will flow through the bulb and it will 'fire'.


FLASH BULB FIRING
HAND TOUCHING WIRE TO CELL

☐ What did the flash bulb look like before and after 'firing'?

☐ For the filament of a flash bulb to 'fire', what gas had to be inside the bulb?

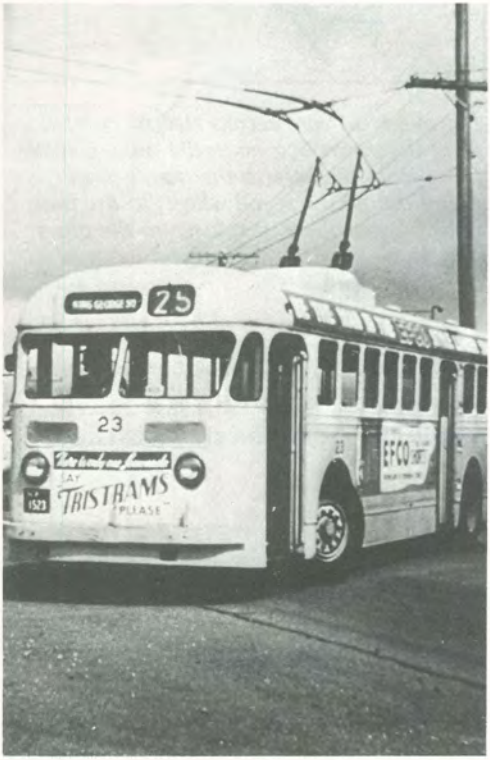
You can check your answers by turning to page 94 of this book.

OPTION

8

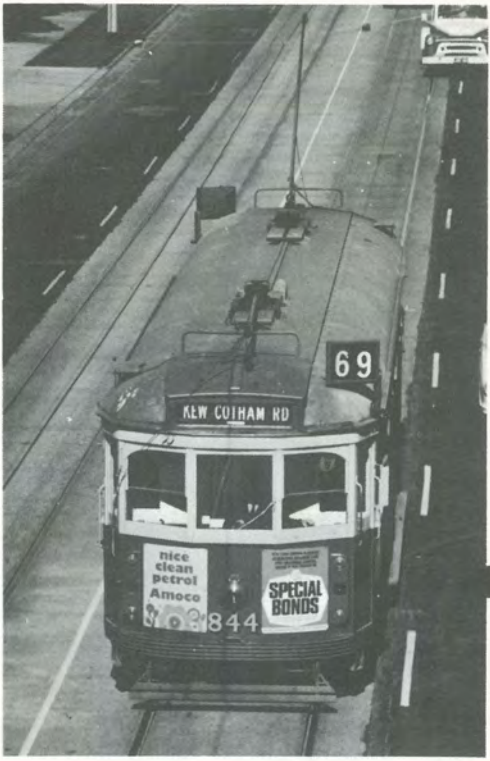
A complete circuit is needed for electric current to flow. Things other than wire can complete circuits.

One, Two, Three Wires

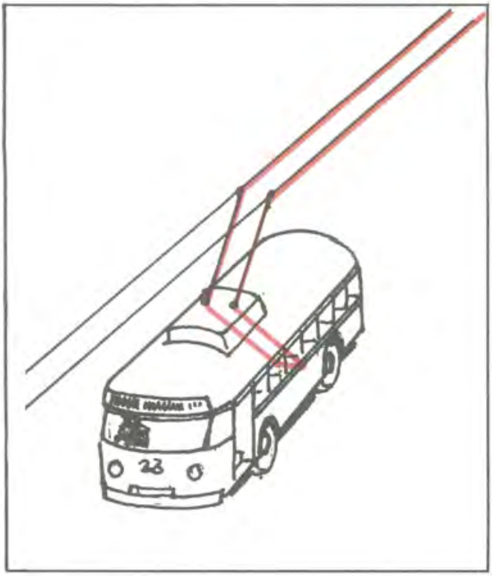


When a trolley bus is moving, each of the two poles is connected to an overhead wire.

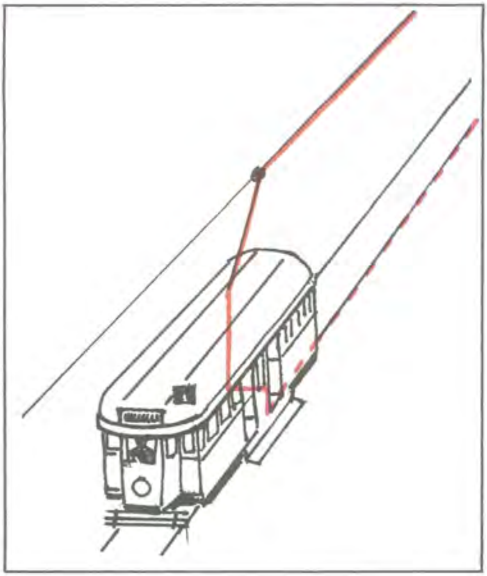
(Photo by courtesy of The Tramway Museum Society of Victoria Ltd.)



Why does a tram need only one wire if a trolley bus needs two?



Current flows from one overhead wire to the motor of a trolley bus, then back to the other wire to complete the circuit.

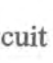


The overhead wire carries electric current from the power source to the tram. Current flows from the wire to the tram's motor, then through the metal wheels to the tram tracks. From there, it returns to the power source. We say that the current has made an **earth return.**

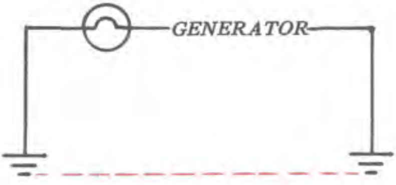
A single wire leads to a bicycle headlamp. Current flows through the frame of the bicycle to complete the circuit.

Any large conductor, such as a car body or a bicycle frame, is called an earth connection.

This symbol is used to indicate an earth connection:



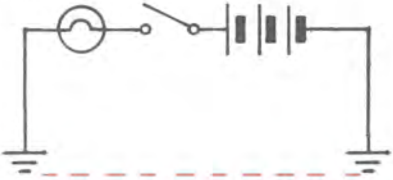
A bicycle-light circuit can be shown like this:



The dotted line indicates the flow of electric current through the bicycle frame.

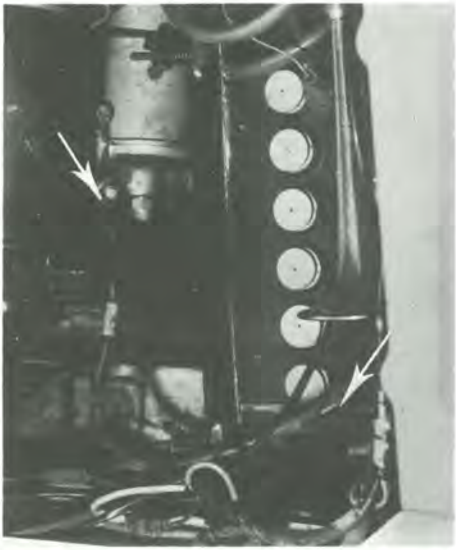
The lights of a car have only one wire leading to each filament. Current flows through the car's metal body and back to the battery.

A car headlight circuit looks like this:



A car battery is a number of cells all in one container. The battery in the circuit diagram above has three cells.

You may like to look at the way a car battery is connected, and locate the return from **'earth'** (the body or the engine) to the **battery**.



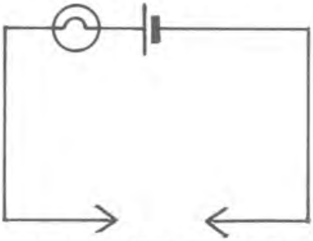
*The earth wire of this car leads from its connection (*top arrow*) with the engine to a battery terminal (*bottom arrow*).*

MAKING AN EARTH-RETURN CIRCUIT

You will need:

- 2 F-clips
- 1 cell
- 1 globe and holder
- 3 pieces of connecting wire
- 2 alligator clips
- 1 rubber band.

Connect the cell and globe like this:



Here are some things which you could use to try to complete earth-return circuits:

- a water tap
- the steel frame of a table or desk
- a bank of lockers
- the frame of a bicycle
- some soil.

The globe will light up when you have a complete earth return.

8.1 On page 26 of your record book, draw a picture of one of your earth connections. Then draw a circuit diagram of it, too.

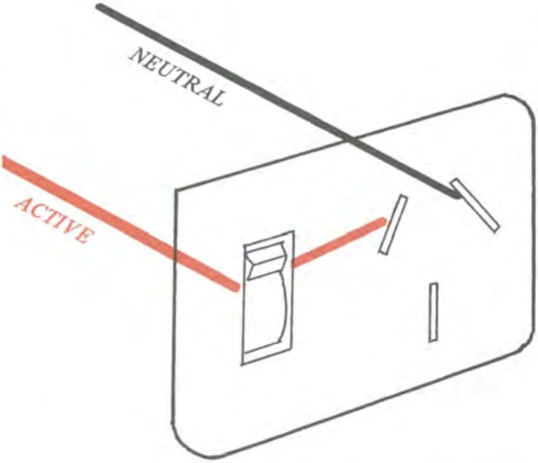
PLUGS AND SOCKETS

Most electric appliances are attached to three-pin plugs. But some, such as electric razors and hair dryers, have only two-pin plugs. These appliances are enclosed in a casing made of insulating material.

All appliances need plugs with at least two pins.

When a plug is 'plugged in' to a socket, the pins make contact with metal which is connected to the wiring. Two pins are needed to complete the circuit through the appliance.

One pin conducts current from the **active wire**, which is usually coloured red. The other pin conducts to the **neutral wire**, which is usually coloured black. The switch should be in the active wire.

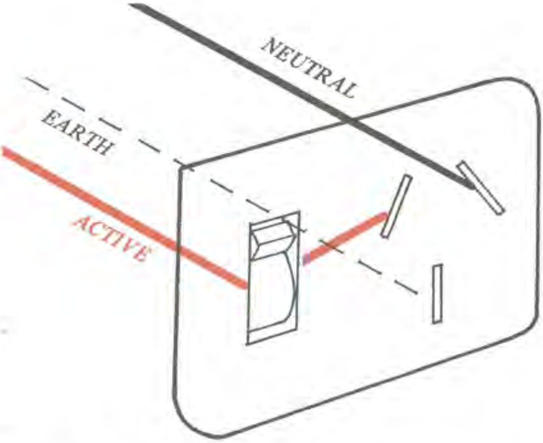


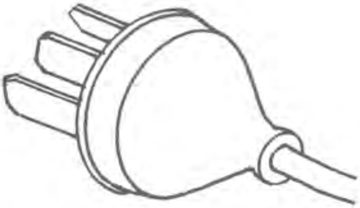
☠ WARNING:

Normally, you would not get a shock if you touched the neutral wire.

DON'T TRY IT–A MISTAKE COULD KILL YOU.

Your body is a high-resistance conductor. It will conduct very little electric current if you touch a 1.5 volt cell (like the ones you have been using). But if you touched a live 240 volt wire, a large current could flow through you to earth.





Why do most appliances have three-pin plugs?

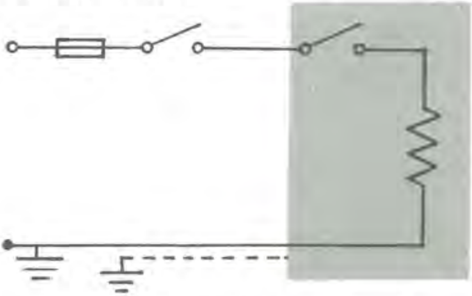
These appliances, e.g. irons, have metal frames or covers. If a live wire inside an iron accidentally touched the metal frame, the whole iron (not just the heating **element**) would become 'live'. If you touched the frame, you could 'earth' the current and suffer a severe electric shock.

However, such pieces of equipment have a third wire that earths the current before you do! This wire is called an **earth wire** and is coloured green or green and yellow. (In the diagrams at right and above, the earth wire is indicated by a dashed line.)

Normally, no current flows through the earth wire. It is just for safety.

The earth wire is connected to the metal parts of an appliance. If an appliance is damaged and a live wire touches the frame, the current flows to earth, through the earth wire. A large current flows because there is a short circuit, and the fuse melts. The appliance is no longer 'live'.

All household circuits involving appliances with metal frames should have earth wires.



Note that the neutral wire is also earthed. The current flowing through the appliance makes an earth return to complete the circuit.

8.2 In your record book there is a drawing of the main parts of a circuit in a house. Using coloured pencils, draw over the active wires in red and the earth wires in green. Leave the neutral wires black.

8.3 Why aren't birds electrocuted when they perch on a power line?

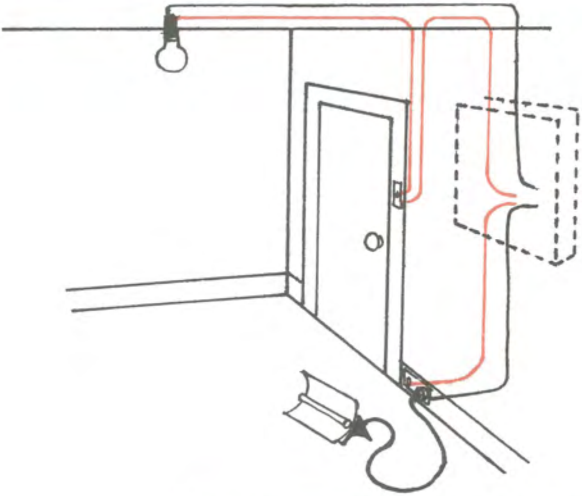
You can check your answers by turning to page 94 of this book.

OPTION

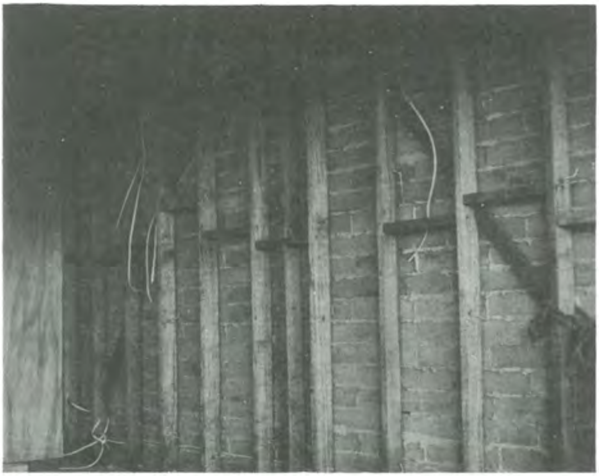
9

With the equipment you used in Simple Circuits you could wire part of a 'model house'.

Wires in the Wall



When a house is being built, the electric wiring is usually put in before the walls are finished. The wires are usually 'hidden' in spaces between the walls, and space between the roof and the ceiling.



You could use cardboard and simple equipment to wire part of a 'model house'.

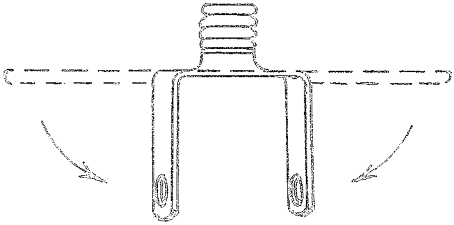
Imagine that the cell is a power station, and that one piece of cardboard is one side of a wall.

To begin, try putting in a wall light and connecting it to a switch. The wall light can be the globe and holder attached to one piece of cardboard.

Decide where the light and switch are going to be. Put the light in first. To do this, begin by bending the arms of the globe holder as shown below.

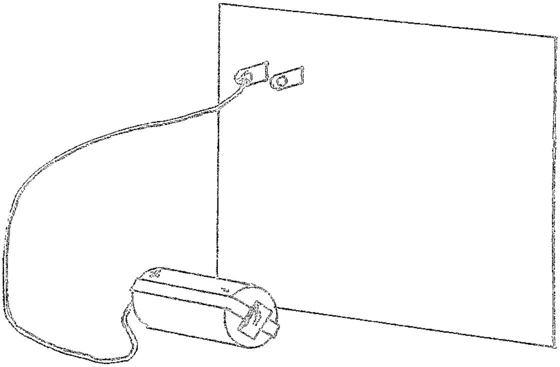
You will need:

- 1 cell, rubber band and F-clips
- 2 pieces of cardboard of the same size
- several pieces of connecting wire
- globes and holders
- paper-clips
- paper fasteners
- 1 pair of wire strippers
- 1 small screwdriver.

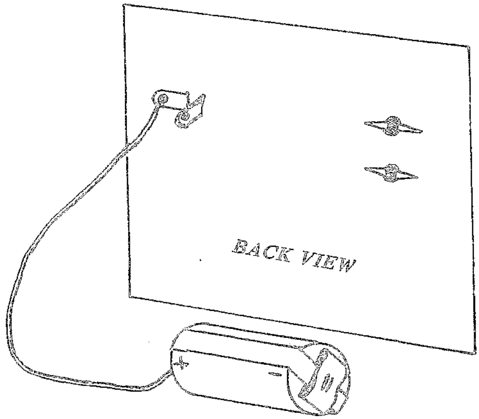


Next, push the arms of the globe holder through the wall. You may need to punch the holes with a small screwdriver.

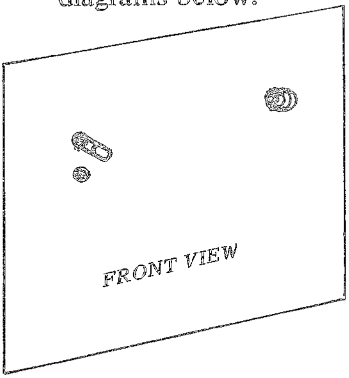
Then join one terminal of the cell to one arm of the globe holder.



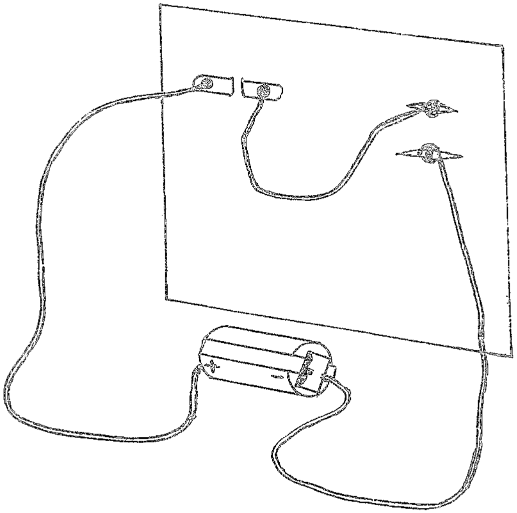
Bend this arm flat
against the wall to keep
the globe holder in place.



To make a switch, arrange
two paper fasteners and a
paper-clip, as shown in the
diagrams below.



You can now wire the switch, as shown below.



Now you can attach the other piece of cardboard, as an outside wall, so that the wires are hidden in the space between.

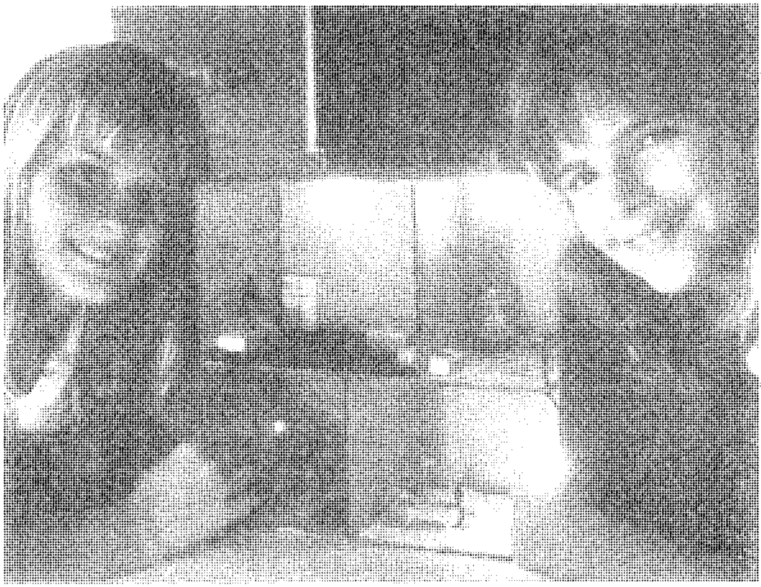
Finally, screw the globe into the holder.

OTHER THINGS TO DO

1 Make a whole 'room' with extra globes and one or more 'power points'. (The extra globes could be made to work from a single switch or from separate switches.*)

There is space on page 28 of your record book for a circuit diagram.

2 You could use 'power lines' and attach your wires to them by alligator clips.



The students in the photo above constructed and wired this model house.

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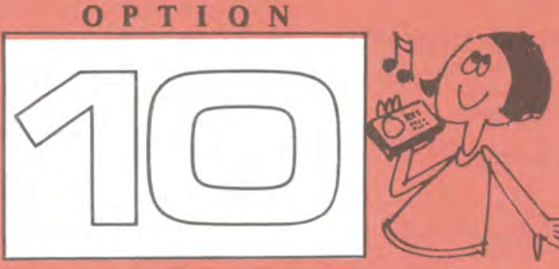
* For some ideas on how to do this, look at Option 6 (Parallel Circuits), pages 60–63.



Most radios look fairly complicated. However, you can make a radio that works from only simple equipment. As you work through the option, you can improve the radio by adding parts.

Making a Radio

It is a good idea to have a partner check each circuit as it is built, since some parts can be damaged if connected incorrectly.

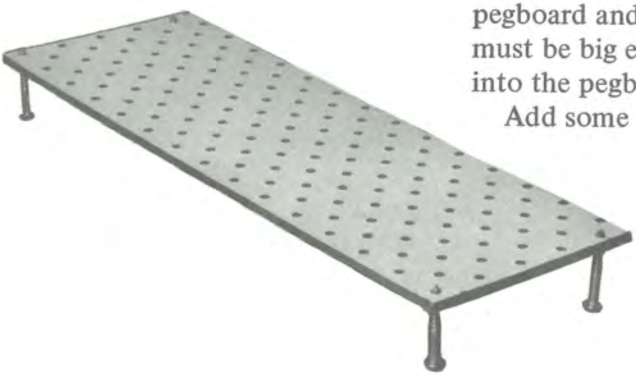
ACTIVITY 1: SETTING UP THE BASIC CIRCUIT

You will need:
- 1 circuit board
- 9 screws–to fit into the circuit board
- 1 set of headphones
- 3 alligator clips
- 1 germanium diode OA91
- 1 piece of wire, about 2 m long
- 1 piece of connecting wire.

Making a Circuit Board

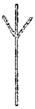
A teacher may supply you with a ready-made circuit board fitted with connectors. If not, perhaps you could make your own, using a piece of pegboard and some screws. The screws must be big enough to screw tightly into the pegboard holes.

Add some 'legs' to the pegboard.



Aerial

THE SYMBOL FOR AN AERIAL IS

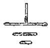


Your radio will need an aerial to pick up the radio waves coming from transmitting stations. A simple aerial can be made using a length of wire at least 10 metres long. (Plastic-coated wire is best.) Generally, the higher and longer the aerial wire, the better the reception. This aerial can be strung between buildings or from the science room to a tree.

Fit an alligator clip to the radio end of your aerial wire.

Earth

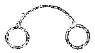
THE SYMBOL FOR AN EARTH CONNECTION IS



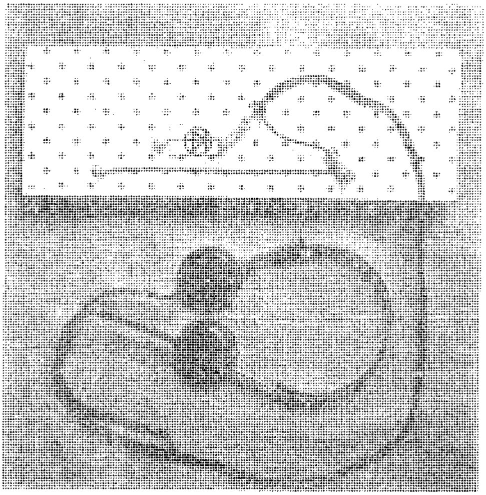
An electrical connection must be made with the earth. Tape the bare end of a wire to a metal water pipe, or bury the end of a wire in the ground. Fit an alligator clip to the other end of the wire so you can attach it easily to the radio circuit.

Headphones

THE SYMBOL FOR HEADPHONES IS



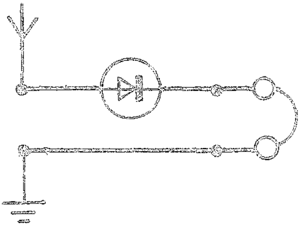
Attach alligator clips to the headphone wires.



Set out the components on your circuit board as shown in the photo above. Make sure that the diode is pointed in the right direction. If it isn't, it won't work.

Try on the headphones and listen carefully. You will not hear anything unless your school is very close to a radio transmitting station.

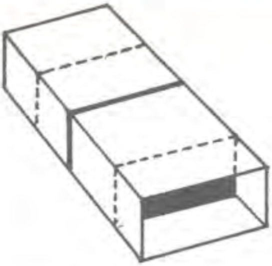
Clip on the aerial and earth wires as shown in the circuit diagram and listen again. You may hear something, but even if you do, there is a chance that the sounds will be very soft. If you add a coil, the sounds will become louder.



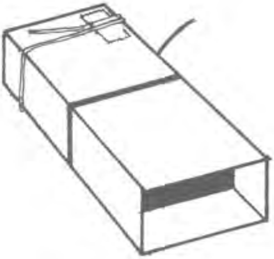
ACTIVITY 2: MAKING AND CONNECTING A COIL

You will need:

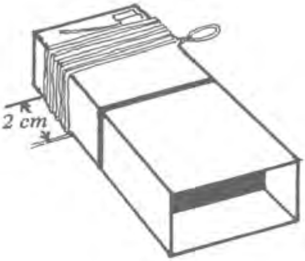
- 18 m varnished copper wire, 22 s.w.g.
- 2 empty matchboxes
- 1 burner
- adhesive tape
- 1 extra piece of connecting wire.



Use one matchbox 'drawer' to hold the two 'outers' together. Fasten with adhesive tape.

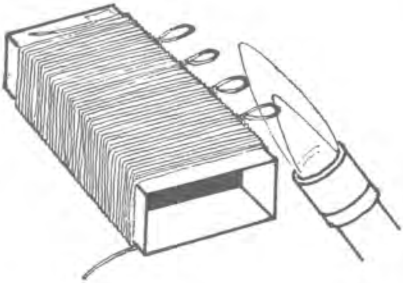


Tape one end of the wire to the box as shown. Wind the wire on very neatly along the box.



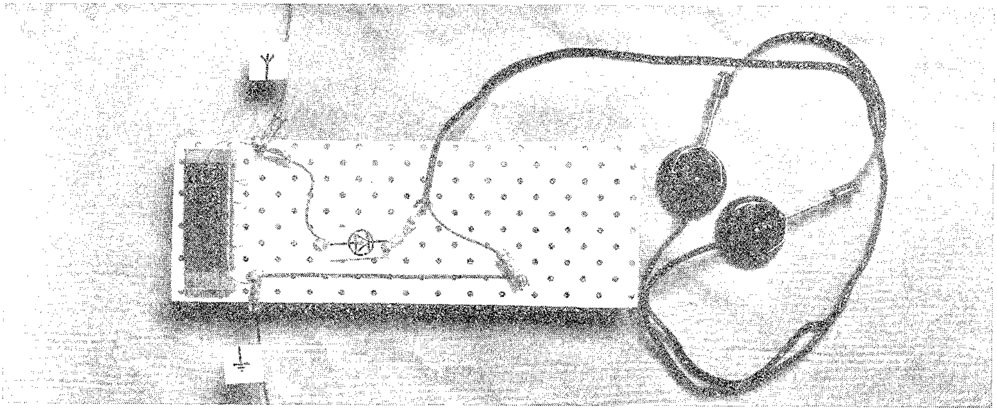
When your coil is about 2 centimetres long, make a connecting loop by twisting the wire as shown. Continue winding the coil and make three more connecting loops. This means there will be one loop every 2 centimetres.

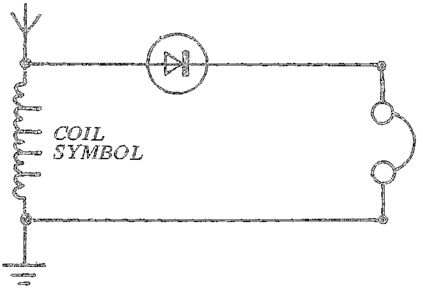
When you reach the end of the coil, tape the wire down, leaving about 5 centimetres of wire for connection to the circuit.



You will need to remove the insulating varnish from the two ends and the four connecting loops. To do this, place them one by one into the hottest part of a burner flame for about two seconds. (The hottest part of the flame is the tip of the blue cone.

The varnish will burn off with a yellow flame, leaving the bare copper for good electrical contact.





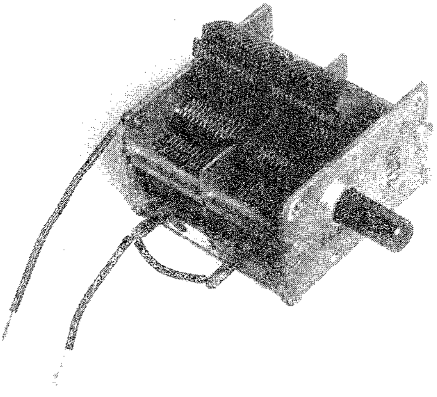
Connecting a Coil

Connect the coil into your radio circuit as shown in the circuit diagram at left.

Look at the coil symbol. Then look at the one on page 2. The symbol here gives more information. There are four connecting loops in the coil you have made, so the symbol shows four places (longer lines) for extra connections. The symbol on page 2 is a general one for all coils.

Your radio should look something like the one in the photo above.

Try on the headphones. You should be able to hear something, but it will probably be a 'jumble' of different stations. One station may be loud enough to drown out the others. To sort out the jumble clearly you will need to add a variable capacitor to the circuit.



VARIABLE CAPACITOR

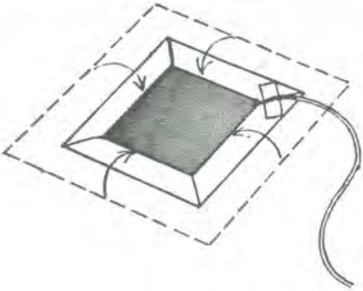
In most radios, the variable capacitor looks like the one shown at left.

If one is available, you could try it 10 in the circuit as shown at the top of page 85. If not, you can make your own (Activity 3, next page).

ACTIVITY 3: MAKING A VARIABLE CAPACITOR

You will need:

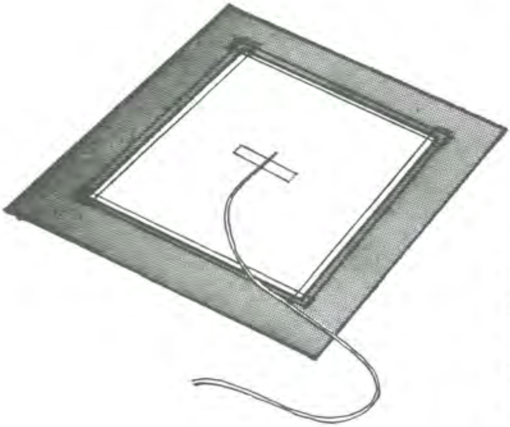
- 1 sheet of cardboard, 30 cm x 30 cm
- 1 sheet of cardboard, 15 cm x 15 cm
- 2 sheets aluminium foil, 20 cm x 20 cm
- 2 extra pieces of connecting wire
- adhesive tape.



Place the small cardboard square in the centre of one of the sheets of foil. Fold over the edges of the foil and tape them down.

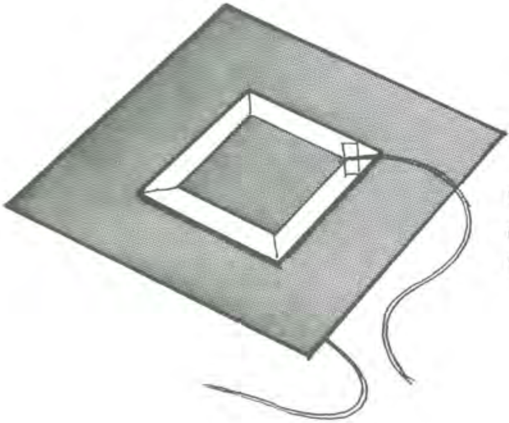
Tape the bare end of one connecting wire to the foil.

This is the **top plate** of the capacitor.



Tape the other foil sheet on to the centre of the large cardboard square and attach a connecting lead.

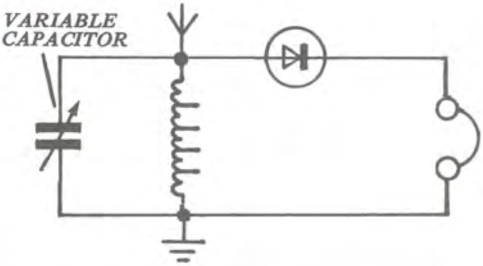
This will be the bottom plate. The large cardboard square will prevent the two plates from making contact.



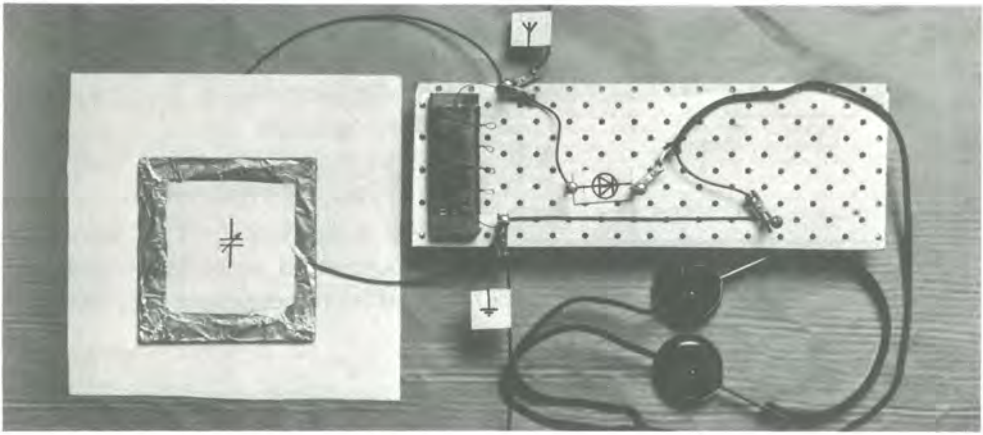
Turn the **bottom** plate over so that the foil is on the **under-side** of the cardboard. Place the top plate on the cardboard.

ACTIVITY 4:
A VARIABLE CAPACITOR IN THE CIRCUIT

Connect the wires from the variable capacitor into the circuit as shown at right.



Your radio should look something like the one in the photo below.



As you listen on the headphones, slowly move the top plate around until you can hear just **one** station. Then move it again until you can hear other stations separately.

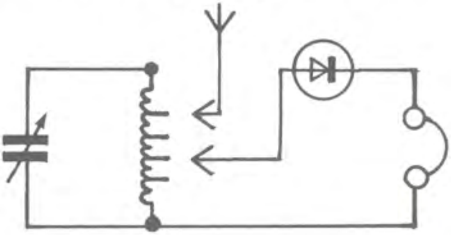
If your school is in or near a large city, you should be able to separate at least three or four stations. In the country, you might separate only one or two.

If you can hear a lot of stations and if you cannot separate them, try different coil connections for the aerial and diode.

The circuit diagram below shows one possible arrangement.

You could try others. Also, try moving the plates apart.

A variable capacitor from an old radio would be better than your home-made one for separating stations.



ACTIVITY 5:
MAKING THE SIGNALS LOUDER STILL

In this circuit you will add an extra power source, and a transistor to amplify the signal.

You will need:

- 1 transistor AC 126
- 1 fixed capacitor 0.022 μF
- 1 resistor 220K
- 2 cells, rubber bands and F-clips
- 3 extra pieces of connecting wire.

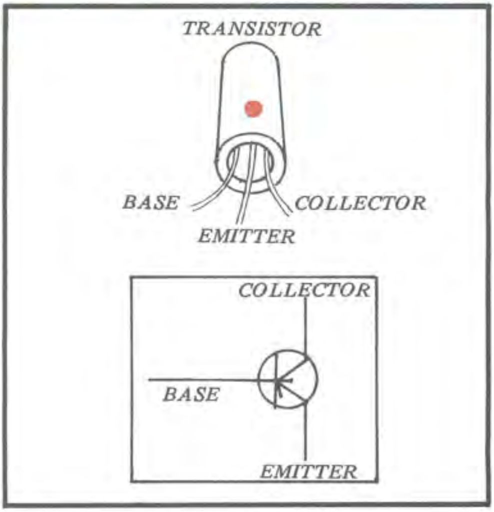
Look closely at the transistor. Three wires come from it.

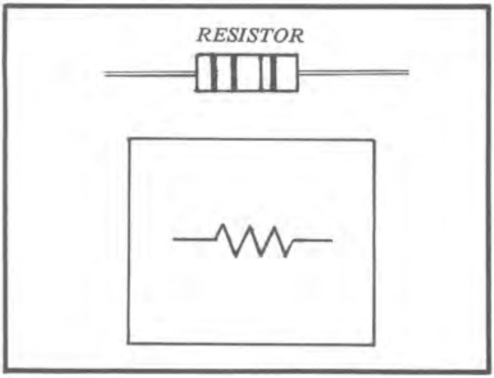
Each wire has a special name and function.

These wires **must** be connected into the circuit correctly, or the transistor might be damaged.

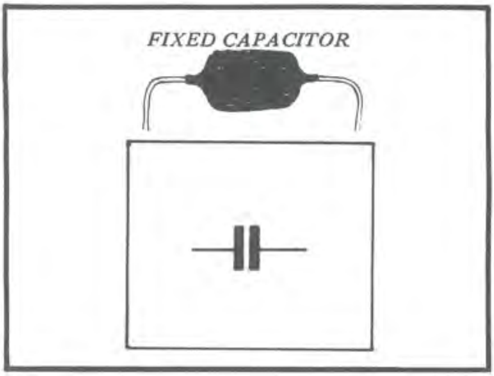
The wire **closest** to the **red dot** (see diagram) is called the **emitter**.

When the power source is added to the circuit, make sure that its **positive terminal is connected to the emitter.**

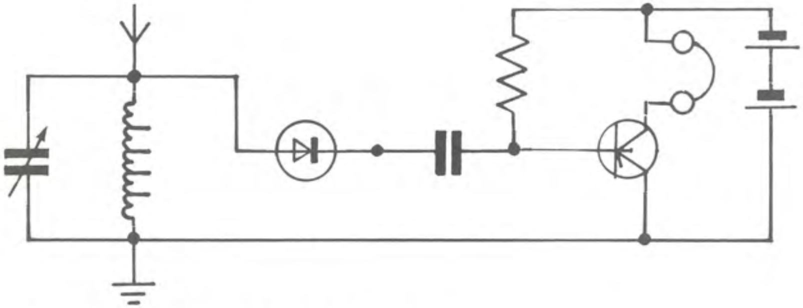




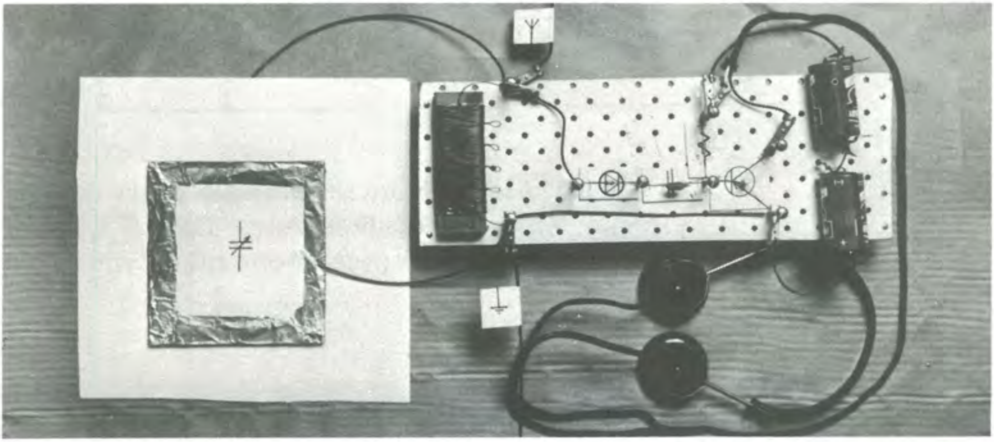
The resistor and fixed capacitor can be placed either way in the circuit.



Set up the circuit as shown in the circuit diagram below.



Your radio should look like this



Before you make the final connection to the power source, have your circuit checked.

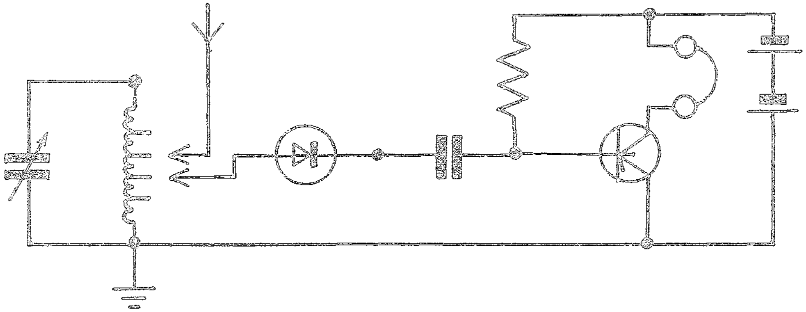
WARNING: An incorrectly connected circuit may cause the transistor or the diode to burn out.

Try on the headphones and select a station. You should hear the station 'loud and clear'.

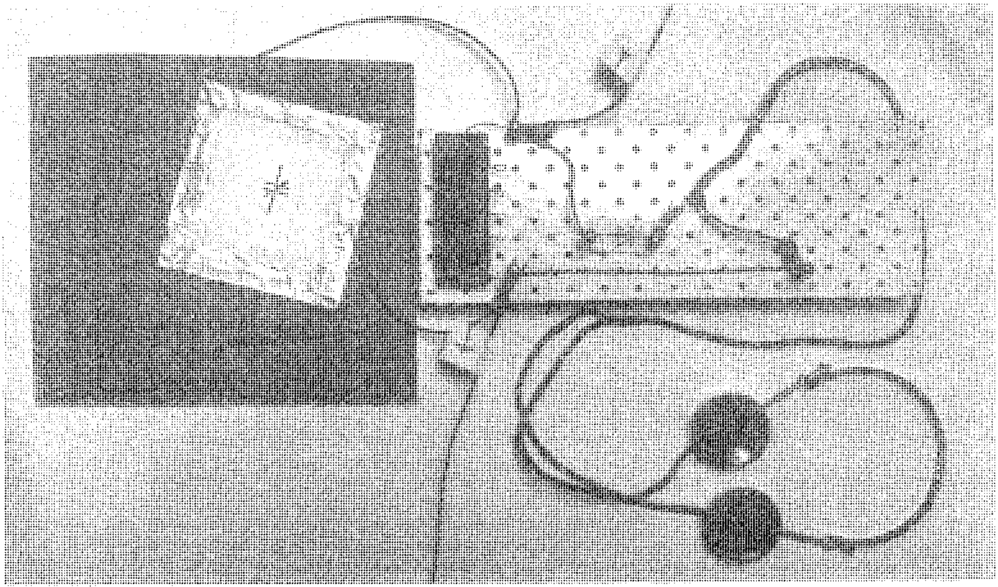
THINGS TO TRY WITH YOUR RADIO

Disconnect the earth wire and 'earth' the radio with your finger. Touch other parts of the radio as well.

If you have time, try different connections of the coil and variable capacitor.



You may like to record the positions of the variable capacitor which give the best results. There is space in your record book from page 29 onward for you to record these.



Check Your Answers

Check your answers with the answers given here. If you cannot agree with a given answer, discuss it with another student, or go back to the particular section of work and read that section again.

If you are still in doubt, ask a teacher.

SIMPLE CIRCUITS

1 It was necessary to close the switch to complete the circuit.

2 The two globes were probably dimmer than when there was only one globe in the circuit.

3 a ...... circuit.

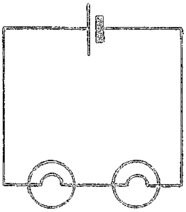
b The globe would not light up, because the connecting wire does not lead to the cell. The circuit is not complete.

4 Taking out the globe breaks the circuit.

5 The circuit consists of a cell, a switch and a globe connected in series.

6 Cell; open switch; closed switch; globe; conductor.

7



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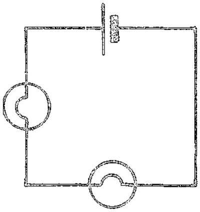

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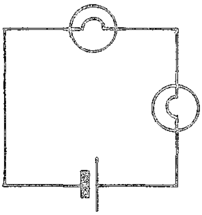

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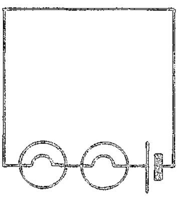
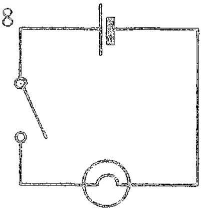


etc.

8



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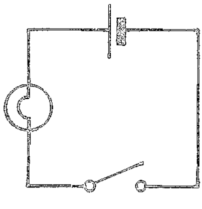

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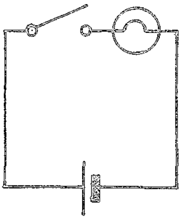

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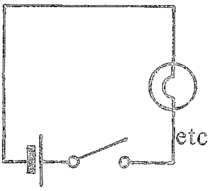


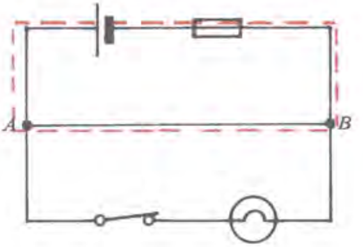
etc.

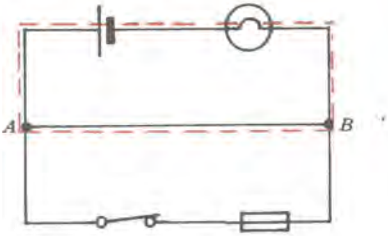
9 Circuit C.

13 Group C should include:
Connecting wire (plastic not taken off ends); string; rubber band; paper; case of ball-point pen; ice-cream stick; water; adhesive tape; skin; air.
Whether or not you were able to detect a flow of current will depend on a number of things. These things include:
How fresh your cell was; the type of ammeter you used; how good your contacts were.

14 The globe probably stopped glowing when you shorted the circuit, and lit up again when you removed the screwdriver.

15





16 Globe goes out.
Fuse 'blows'.

Fuse will not 'blow'.

17 A household switch stays on until switched off. You are probably using switches which need to be pressed down to stay closed.

18 Plastic is an insulator.

19 Careful Charlie would probably switch the power off and pull the plug out, and wait for the toaster to cool down. Then he would try to get the toast out.

20 The fuse would become hot and would melt. In this way, the circuit would be broken.

21 The circuit wiring would become hot.

22 If a household circuit without fuses were shorted, the wiring might become hot enough to cause a fire.

23 You may have guessed that water can conduct an electric current. Water from wet hands could complete a circuit from the wiring of a switch, along the surface of the insulation, to you.

24 It is dangerous because the boy would complete a circuit if he touched both the metal guttering and a live wire, and would be electrocuted. (It is even more dangerous if parts of the kite conduct electricity.)

OPTION 2: HOT STUFF

2.2 If you don't cover an element, part of it becomes too hot and can melt.

2.3 It is illegal to manufacture electric jugs with lids that can open when the lead is plugged in. If the lid can be opened when a jug is switched on, someone may put his hand into the water and receive a shock.

2.4 Coiling allows a greater length of wire in a small space. For the same current, the longer the wire, the more heat will be transferred to the water.

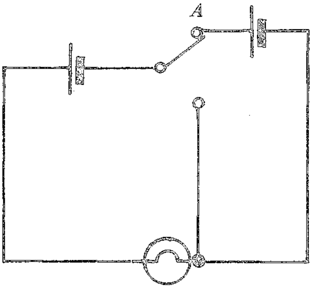
OPTION 3: A CARBON ARC

3.1 The 4B pencils should work best.

3.4 Most of the time, air behaves as an insulator. But, as you have seen, it is possible to make a spark jump through air. Lightning is really a very long spark.

OPTION 4: MORE CELLS

4.1 The globe is brighter when both cells are in the circuit, i.e. for this circuit diagram:



4.2 The globe should not light up in either case. However, if one of the cells is fresh and the other is weak, you may see a dull glow from the globe.

4.3 As more cells are added in series to the circuit, you should notice a brighter glow. A general rule is: The more cells there are in series, the brighter the globe will be.

4.4 So much current would flow through the filament that it would become very hot and would melt. That is, the globe would 'burn out'.

OPTION 5: THE LONG AND THE SHORT OF IT

5.1 The length of thin nichrome wire in the circuit when the globe goes out is nearly 1 metre.

5.2 The length of thick nichrome wire in the circuit when the globe goes out is about 1.75 metres.

5.3 When there are 5 centimetres of thin nichrome wire in the circuit, the globe is brighter than when there are 30 centimetres of thin nichrome. So there is a greater current with 5 centimetres of wire in the circuit.

5.4 Thick nichrome wire has a lower resistance than thin nichrome wire. So more current will flow through 5 centimetres of thick wire.

5.5 You probably won't be able to notice any difference in brightness.

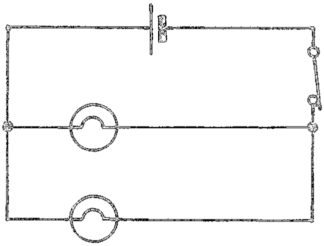
5.6 When you have 25 metres of copper wire in the circuit, the globe will probably appear dimmer than when there was only 1 metre.

5.7 The globe will be very dim or it will not be glowing at all. (It will depend on how fresh your cells are.)

5.9 The best connecting wire is copper wire, because it has a lower resistance than nichrome wire. Thick nichrome is better than thin nichrome, but both have a much higher resistance than copper wire.

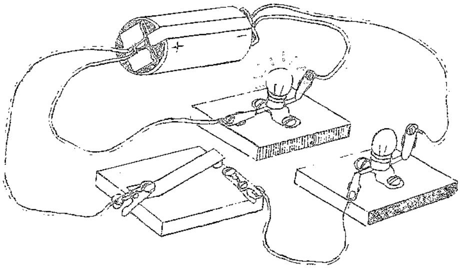
OPTION 6: PARALLEL CIRCUITS

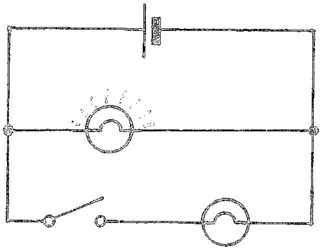
6.1 When the switch is closed, there are two paths through which the current can flow. In this case it will go through both. It may be easier for you to trace the paths if you draw a circuit diagram:



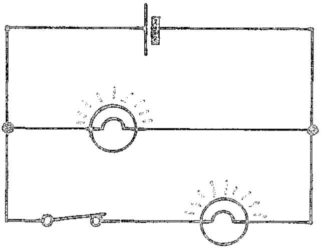
6.2 Both globes are slightly dimmer than when only one globe was in the circuit. However, it may be difficult to be certain.

6.3 One globe only is alight when the switch is open.





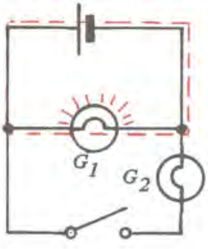
6.4 Both globes are alight when the switch is closed.



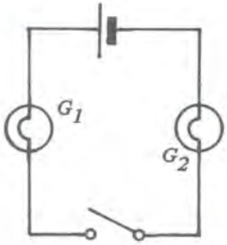
6.6

CIRCUIT	A	B	C	D
Globe(s) alight when switch is open	G_1	neither	both	G_1

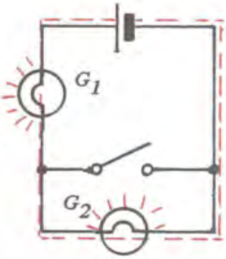
If you don't agree with any of these answers, trace the path of the current as shown below by the dashed lines.



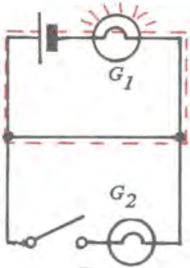
A



B



C



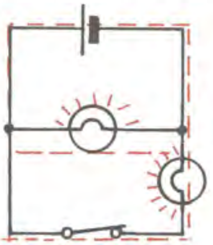
D

6.7

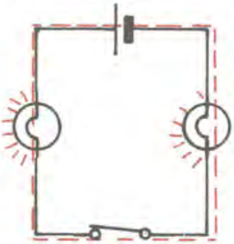
CIRCUIT	A	B	C	D
Globe(s) alight when switch is closed	both	both	G_1	G_1

6.8 Which of the circuits shows globes in parallel? A.

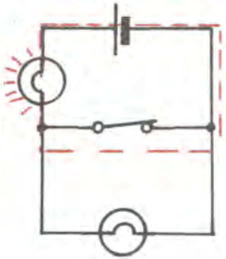
6.9 Which of the circuits shows globes in series? B, C and D.
The easiest way to find if globes are wired in series or parallel is to trace the path of the current when the switch is closed. If the current has to travel by more than one path to reach **both** globes, then the globes are in parallel.



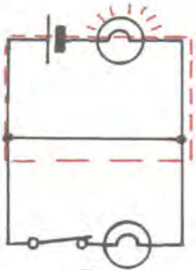
A



B



C



D

OPTION 7: INVESTIGATING A LIGHT GLOBE

7.1 A cream-coloured substance is deposited on the inside of the glass, and the filament breaks.

7.2 All of it should have burnt.

7.3 The magnesium burns to form a white powder.

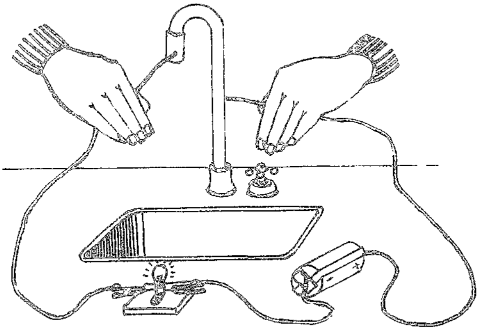
7.4 The bubbles might have escaped too quickly for you to count them! The number of bubbles which escape depends on how big they are, and this depends on the size of the hole you filed.

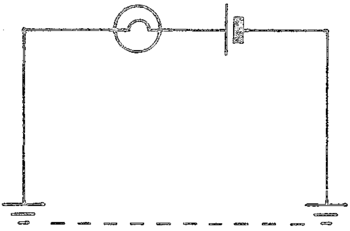
7.5 The globe should become more than half-filled with water.

7.6 If there were no gas inside the globe, you would not have seen bubbles escaping.

OPTION 8: ONE, TWO, THREE WIRES

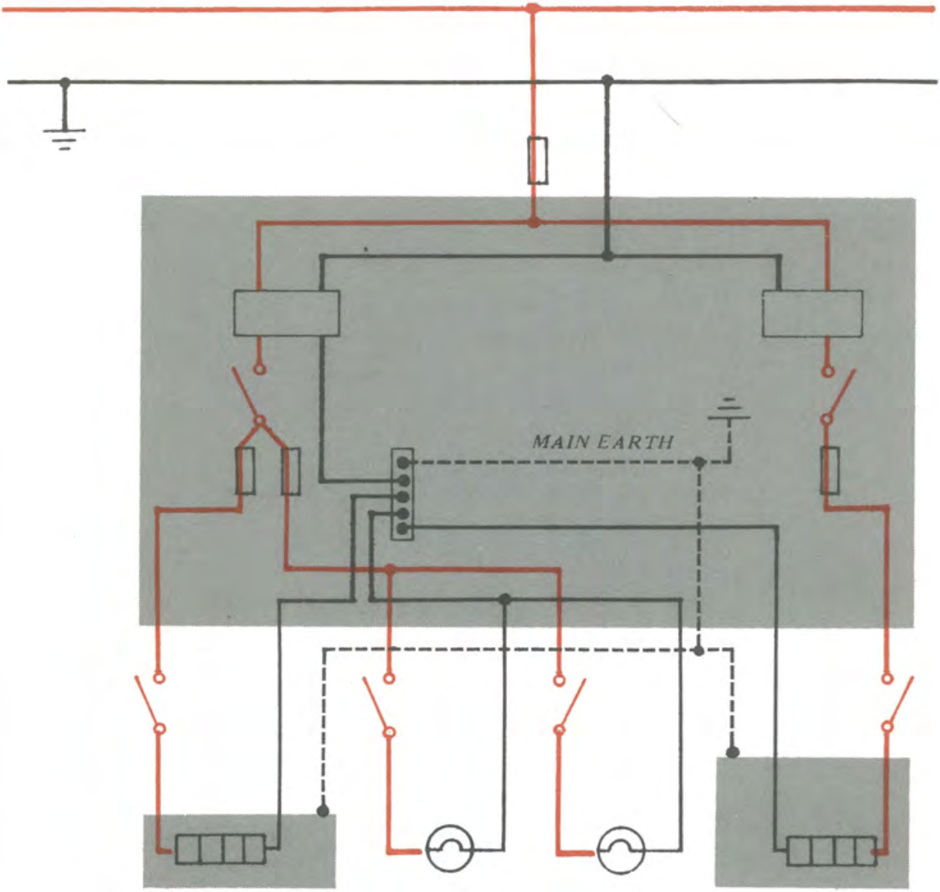
8.1 If you used a water tap as the earth return, your diagram could look like this.





CIRCUIT DIAGRAM

8.2 See the diagram on the opposite page.



You should also have coloured the dashed lines in green.

8.3 A bird is in contact with only **one** power line, so does not complete a circuit.

TEST YOURSELF–SIMPLE CIRCUITS

1 Cell.

2 Junction of conductors.

3 Switch (closed).

4 Switch (open).

5 Conductor.

6 Globe.

7 Fuse.

8 A

- B This circuit diagram shows two cells, whereas the drawing of the circuit shows only one.
- C This circuit diagram shows two cells and a closed switch, whereas the drawing of the circuit shows only one cell and an open switch.
- D This circuit diagram shows a closed switch, whereas the drawing of the circuit shows an open switch.

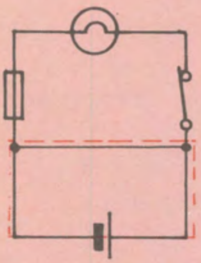
9 C This is the only circuit in which the globe is alight when the switch is open.

10 D

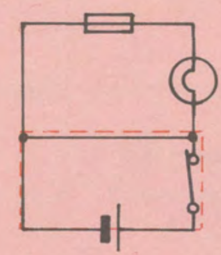
11 B The movement of the needle showed that current was flowing. The fact that the globe did not light up showed that the current was weak.

12 C

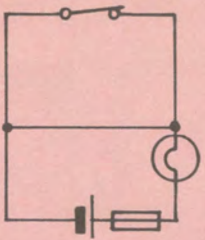
13 **D** Each of the diagrams below shows the path through which a large current will flow when the short is made.



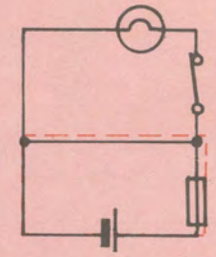
A



B



C

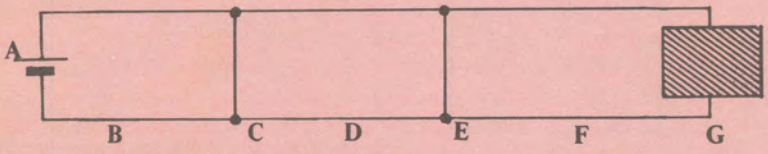


D

A, B The fuse will not blow because it is not part of the short circuit.

C The fuse in C will not blow because the resistance of the globe stops too much current from flowing.

14 **C,E** Using bare wires on the metal as the students did means that the supports become part of the circuit. A circuit diagram shows the problem.



15 **C** C is true. If the mains switch was turned off, no current could flow to any part of the house.

A The man could have touched a faulty switch or connection.

B Thick shoes and gloves usually give some protection, because they are made of insulating material, but may not prevent a person from being electrocuted.

D Fuses do not protect a person from being electrocuted. By the time enough current to blow the fuse has gone through both it and a person, the person may be dead.

Test Yourself continued next page

16 **A,C** In each of these arrangements the two globes form part of a complete circuit which does not contain the switch.

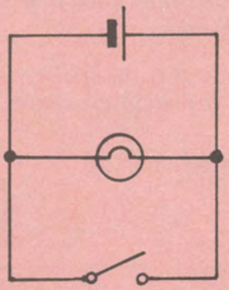
17 **D,E**

- A The closed switch shorts part of the circuit, so one globe goes out.
- B The cells are connected - to - , so no current flows.
- C The closed switch shorts the circuit, so both globes go out.

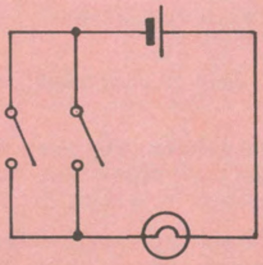
18 **C**

19 **B** The cells are connected - to -, so no current flows.

20



21



Your circuit diagrams may look different from these and still work.

GLOSSARY

active wire. The wire from power supply to appliance which must always contain a fuse. (Page 74.)

alloy *(AL-oy).* A mixture of two or more metals. (Page 44.)

ammeter *(AM-eater).* An instrument which measures electric current. (Page 14.)

argon *(AH-gon).* A gas found in small quantities in the air. Most light globes are filled with argon. (Page 68.)

battery *(BAT-er-ee).* Two or more cells connected in series. (Pages 53 and 73.)

cell *(sell).* A source of electric energy. (Page 6.)

circuit breaker. A device which stops electric current flowing in a circuit if the flow of current becomes too much for safety. (Page 25.)

conductor *(kon-DUCK-tor).* Anything through which electric current can flow. (Page 16.)

earth. Any very large **conductor.** (Page 73.)

earth connection. A **conductor** (usually a wire) which is connected to a very large conductor. (Page 72.)

element *(ELL-a-ment).* A coiled wire (or other **conductor**) which becomes hot when electric current flows through it. (Page 26.)

filament *(FILL-a-ment).* Very thin wire. (Page 13.)

fuse. A wire which melts when a current which would damage a circuit flows through it. (Page 19.)

incandescent *(IN-kan-DESS-ent).* Hot enough to give out light. (Page 64.)

insulation *(IN-su-LAY-shun).* Material made of an **insulator.** It prevents contact with bare **conductors.** (Page 5.)

insulator *(IN-su-lay-tor).* Material which usually lets very little electric current pass through it. (Page 17.)

mica *(MY-ka).* An **insulating** mineral which can be used as a core for **elements.** (Page 44.)

neutral wire. The wire which completes the circuit from appliance to power supply. (Page 74.)

nichrome *(NY-krome).* An **alloy** of the metals nickel and chromium. Some types of nichrome also contain small quantities of other metals. (Pages 44 and 56.)

parallel circuit. A circuit in which the current can take more than one path. (Page 60.)

resistance *(ree-ZIS-tance).* The extent to which a **conductor** resists the flow of electric current. If a conductor has a high resistance, it means current has difficulty in flowing through it. (Page 16.)

series *(SEER-eez)* **circuit.** A circuit which has things connected one after the other. There is only one path through which the current can flow. (Page 9.)

short circuit. Occurs if two points of a circuit are joined by a **conductor** of much lower **resistance** than the rest of the circuit. (Page 19.)

terminal *(TER-min-al).* A place on a **cell** or **battery to** which connections can be attached. (Page 10.)

tungsten *(TUNG-sten).* A hard metal which melts at a very high temperature. It is used to make **filaments** in light globes. (Page 66.)

Many people were involved in the development and production of ASEP units.
As well as the ideas and suggestions contributed by ASEP staff members, valuable help was given by consultants, students and teachers throughout Australia during trials.
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